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Japan: Asian Semiconductor Industry Assessed

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95FE0278A Munich STAATLICHE FOERDERUNG DER HALBLEITERINDUSTRIE IN JAPAN in German 1994 pp 1-36, 151-189

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[FBIS Translated Excerpts]

JAPAN

Government Support of Semiconductor Industry in Japan

Japanese firms occupy a top position alongside U.S. companies in the semiconductor industry's global competition. In trade policy discussion the charge against Japan is that this corporate success can allegedly be causally attributed to the systematic support of this branch. In what follows, this charge is examined in detail on the basis of a systematic description of all of Japan's support activities in this sector.[1]

1. The Position of Japan's Semiconductor Industry in Global Competition

In 1993, Japan's semiconductor industry realized a global share of 41.4 percent with a production volume of nearly 52 billion German marks [DM] after currency conversion. The lion's share, nearly DM40 billion, was in the integrated circuits (ICs) segment (see table one). After the Japanese attained the top position in the world in 1985 (measured by sales) and were able to expand it even to more than 50 percent up until the end of the eighties, in 1993 they were again forced to yield the top position to the U.S. competition (U.S., 1993: 41.9 percent). Still, despite the downturn in growth concomitant upon the recent recession (1991-1994), Japanese firms continue to shape the branch's global competition to a considerable degree.

Table 1: Growth of Japan's Semiconductor Industry, 1989-1993—in millions of DM

Discrete Semiconductors

Year	Production	Exports	Imports
1989	8,919	2,518	560
1990	7,940	2,281	537
1991	9,408	2,840	741
1992	3,237	not applicable [n.a].	n.a.
1993[1]	9,946	n.a.	n.a.

Japan's market shares in 1991: Toshiba—24 percent; Matsushita—15 percent; Hitachi—12 percent; NEC—12 percent; Rohm—9 percent

Integrated Circuits

Year	Production	Exports	Imports
1989	40,182	15,679	4,234
1990	32,576	12,324	4,194
1991	38,581	13,729	5,025
1992	33,873	15,404	4,537[2]
1993	42,414	21,428	n.a.

Japan's market shares for 1991: NEC—21 percent; Toshiba—17 percent; Hitachi—13 percent; Fujitsu—13 percent; Mitsubishi—10 percent

1. Ifo [Institute for Economic Research] projection through extrapolating the months of November and December 1993

2. According to MITI [Ministry of International Trade and Industry]

Sources: Electronic Industries of Japan; NIKKEI SANGYO SHIMBUN; Dodwell (1993)

A high rate of exports (for ICs in 1993: 50.5 percent) typifies the high level of the technological and economic competitiveness of Japan's semiconductor industry. In this context, however, it should be noted that the weak demand on Japan's domestic market in the early nineties induced Japanese firms to intensify overseas sales of their products. The most important region for exports of Japanese ICs is Asia (1991: 51 percent), followed by the U.S. (1991: 32 percent) and the EU [European Union] (1991: 13 percent). Conversely, in recent years, because of the U.S.'s strong trade-policy pressure, foreign imports increased. In the last quarter of 1993, after a temporary decline, they again realized a 20-percent share of the domestic market. The IC imports market is dominated by U.S. manufacturers who, in 1991 alone, cornered 69 percent of all imports. The shares for Asia and Europe (Europe's share of the domestic market is less than 1 percent) are distinctly lower.

The takeoff of Japan's semiconductor industry that historically had its start in Sony's transistor production in the early fifties, occurred in the seventies—concomitant with the breakthrough of Japanese consumer and office electronics on the global market. Through a strategy of intense monitoring of technology in the U.S., licensing and product imitation together with numerous marginal improvements, Japanese firms successfully caught up technologically and in the eighties outstripped U.S. industry in numerous areas. Currently, five of the world's 10 largest semiconductor firms are headquartered in Japan, 10 of the largest 20 are headquartered in Japan (also see table three). At present, nowhere except in Japan does the semiconductor industry possess a comparably broad product spectrum. Significant competitive advantages for Japan's semiconductor industry also are to be found in the financial power of the firms and in the existence of an efficient equipment and materials industry encompassing the entire spectrum of availability.

In Japan the most important customer for semiconductors is consumer electronics, albeit with a steadily declining share, followed by information technology.

Demand from other electrical engineering segments is distinctly lower (see table two). Accounting for this applications structure are Japan's global market successes in household electronics and in computer peripherals. On the product level, the strength of Japan's firms resides in the area of memory chips, although in the meantime in the DRAM [Dynamic Random Access Memory] sector, Korean rivals have taken over the initiative. Alternatively, in the microprocessors sector and the follow-on product level (PCs [personal computers], mainframes), Japanese firms have not managed to break the hold of U.S. firms. In Japan, Fujitsu (25 percent), NEC (20 percent) and Toshiba (13 percent) dominate the rapidly growing ASICs [Application-Specific Integrated Circuits] segment (1991 production volumes: DM5.4 billion). In most segments Japan's equipment and materials industry determines global competition (for example, for quilters: Nikon, Canon; for synthetic epoxy resins: Sumitomo Chemical, Nippon Kayaku, Dainippon Ink).

Table 2: Semiconductor Applications in Japan, by Branches, 1991—in Millions of DM and in percent

Information technology	32.4 percent
Consumer electronics	42.0 percent
Telecommunications	11.4 percent
Industrial electronics	9.7 percent
Motor vehicle electronics	4.2 percent
Government demand	0.2 percent
Market volumes	DM47,680 million
including:	
—discrete semiconductors	DM9,407 million
—integrated circuits	DM38,273 million

Sources: Electronic Industries of Japan; NIKKEI SANGYO SHIMBUN; Dodwell (1993).

Table 3: Japan's Top Semiconductor Firms, 1992—in millions of DM, Shares in percent

Firm	Semiconductor sales	Global share	Share of corporate turnover	Semiconductor R&D outlays	Semiconductor plant investment
NEC	7,593	7.6	17.5	1,269	862
Toshiba	7,291	7.3	12.7	1,251	985
Hitachi	6,006	6.0	6.3	1,276	739
Fujitsu	3,981	3.9	9.3	800	776
Mitsubishi	3,451	3.5	8.7	770	616
Matsushita	3,044	2.9	3.4	733	185
Sanyo	2,160	2.1	10.9	351	414
Sharp	2,112	2.1	11.6	432	369
Sony	1,720	1.8	3.7	524	n.a.
Oki	1,491	1.6	20.4	190	250

Sources: Dataquest, Nomura Research Institute, Japan Development Bank.

Footnotes:

1. For a detailed presentation and a detailed explanation of the support situation in other countries see: Hilpert, H. G., Ochel, W., Penzkofer, H., Reinhard, M., in collaboration with E.v. Pilgrim and H. Schedl: Internationale Wettbewerbsverzerrungen in der Halbleiterindustrie [Distortions of Global Competitiveness in the Semiconductor Industry], Duncker & Humblot, Berlin-Munich, 1994 (coming out probably in December).

2. Philosophy Underlying Economic Policy

Japan's rise to top technological and economic power between the end of the Second World War and the present day went hand in hand with an intensive industrial and growth policy designed for the long haul. The effectiveness and efficiency of Japan's industrial policy in terms of the country's economic success are assessed controversially—depending on one's viewpoint—in the West. But there seems to be no disputing the fact that in Japan the interaction of industrial policy in the private and public sectors is successful under quite specific socio-cultural and institutional framework conditions. The characteristic fundamental patterns include the existence of a decision-making institution as the principal platform for official industrial policy (MITI), the close interweaving and comprehensive consensus on

goals and resources between the private sector and government, supported by extensive networks for information and relationships plus quasi-governmental institutions and corporations and the classification of industrial policy as formal policy that may not be directed against the forces driving the competitiveness of the market sector. Japan's industrial and economic policy is essentially results- and not process-oriented.

Implementation of industrial policy was successful into the eighties as the result of intense, detailed regulation of practically all areas of corporate decision-making. Currently, as a result of numerous liberalization measures the formerly all-encompassing apparatus for industrial policy applying to virtually levels of economic activity has lost much of its cutting edge. On the basis of close personal relations by economic policy makers with private sector decision-makers and by means of the instrument of administrative regulations, the government's capabilities for influence remain far-reaching even now. The significance of Japan's industrial policy, therefore, generally resides not in the quantitative scope of the support resources allocated but more so in their qualitative intensity on the micro-level. But the widespread notion of Japan as a private sector corporation strictly controlled by a superpowerful bureaucracy ("Japan, Inc.") hardly reflects the reality. The consensus between firms and MITI is crucial for the implementation of industrial policy.[1]

The electrical engineering industry and the semiconductor industry derived from it are branches that have been intensely nurtured, in particular, in Japan from the very outset by the regulatory and controlling power of the government.[2] Support for this branch of the private sector by means of low-interest loans and R&D subsidies dates back to the year 1957 and lasted into the eighties (chart one). In the seventies and the eighties, the semiconductor industry shifted to the center of MITI's industrial policy activities and received more comprehensive support and sponsorship than other branches. Even though semiconductor technology is increasingly supported by other ministries too as well as non-MITI institutions in Japan, MITI thus far maintains overall control of industrial policy for microelectronics. Semiconductors are "industry's bread and butter," the way steel was from the postwar era until the early seventies. Semiconductors are key components for virtually all branches of industry. The spread of basic microelectronics technology enabled the growth drive in applied industries and acceleration of sectoral structural change in the national economy. Since then, however, environmental and biotechnologies have replaced the semiconductor industry in the ranking of industrial sectors of the future supported on a priority basis. In Japan the highest financial allocations are going to nuclear technology and space travel, two sectors in which private sector activities would virtually completely lag behind, absent government influence.

Chart 1: Industrial Policy Support for the Information and Semiconductor Industry in Japan, 1957-1985—data in billions of DM

Legal basis	Tenor	Subsidy	Loan
Law on temporary measures for support of electrical engineering industry (1957-1971)	R&D subsidies	57	
	Low interest loans by Japan Development Bank (JDB) for costs of streamlining production (1957-70)		159
	Japan Electronic Computer Co. Ltd. (1961), financed by JDB (1961-78)		4,041
	Subsidies for a computer development laboratory	4	
	Subsidies for comprehensive computer industry R&D projects	111	
	Founding of the "Information Technology Support Agency": (1970), financed by long-term credit banks	88	448
Law for temporary measures to support electronics industry and machine building (Kidenho) (1971-1978)	JDB and SBFC loan (1971-1977)		147
	Subsidies for R&D on strategic technologies (1971-77)	40	
	Subsidies for a pattern information system development laboratory (1971-80)	250	
	Subsidies for development of new type of computer (1972-76)	648	105
	JDB loan to the computer industry (1973-74)	35	
	Subsidies for development of ICs (1973-75)	29	
	Subsidies to the data processing industry (1976-79)	255	
	Subsidies for development of very large scale integration (VLSI project)		

Chart 1: Industrial Policy Support for the Information and Semiconductor Industry in Japan, 1957-1985—data in billions of DM (Continued)

Legal basis	Tenor	Subsidy	Loan
Law for temporary measures for support of specific areas of machine building and information processing industry (Kijoho) (1978-1985)	JDB loan for production plants and equipment (1978)		70
	Subsidies for basic technologies R&D for next generation of computers (1980-83)	188	
	Large project for development of an optical measurement and control system (1981)	151	
	Subsidies for development of optical systems (1981)	25	

Sources: MITI; translation by the ifo Institute.

In the eighties MITI conducted industrial policy benefiting the electrical engineering and semiconductor branches with a multifaceted mix of tools (Fransman 1990; Okimoto 1989; Semiconductor Industry Association 1983):

—Stimulating technology import by limiting direct foreign investments (forced joint-venture) or support of licensing;

—Targeted allocation of resources (credits, foreign exchange, information, human capital)

—Regulation of competition (limiting number of suppliers, cartel formation, stimulating private demand, government procurement);

—Protection from foreign competition through tariffs and nontariff trade barriers; support of exports;

—"gentle" administration of patent protection and long waiting periods for basic patents;

—R&D subsidies (credits, possible deductions) and domestic R&D projects;

—Development and dissemination of industrial policy visions.

As a result of Japan's maturing industrially into the top nation for its economy and technology, and forced by foreign pressure to liberalize and open up its domestic markets, in the eighties MITI gradually dismantled that extensive apparatus. At present only the last two instruments still hold any substantial significance. But that does not mean that Japan has kissed off the concept of industrial policy support by specific sector. Only the goals and the resources have undergone change. The endeavored support of domestic industry to gain competitive advantages, and as far as possible, technological leadership in knowledge- and technology-intensive branches of the economy, cannot be realized with resources that proved to be adequate for the process of catching up industrially. As the result of a reorientation, new instruments, new institutions and new financing mechanisms have emerged. After discontinuation of the "Kijoho" in 1985, the "Basic Research Facilitation Law" laid the legal basis for governmental combined research and the establishment of the Japan Key Technology Center (JKTC). The current focuses are precompetitive cooperative research activities designed for the long term. Moreover, there is an endeavor to broadly expand the infrastructure for technological progress. As a consequence, current industrial policy in Japan is essentially research and technology policy.

Footnotes:

1. For a broader description of Japan's industrial policy see: Hilpert (1993), Watanabe (1992a and 1992b), Wattenberg (1992).

2. To be sure, MITI's first industrial policy act in the semiconductor sector constitutes a negative instance of government intervention in Japan. In 1953 MITI at first refused approval of foreign exchange ($25,000) for the then unknown Sony firm for the transfer of transistor technology from Western Electric. Thereupon Sony quickly signed the contract and transfer of license, confronting MITI with an accomplished fact and subsequently got the authorization it needed.

3. Support for R&D in Semiconductor Technology

Japan's technology policy for the domestic semiconductor industry is focused on two sectors:

—the implementation of domestic research projects in the precompetitive sector,

—the cultivation and development of extensive basic research in microelectronics.

For such responsibilities there are a spate of governmental or quasi-governmental institutions under the administrative supervision of MITI and the STA (Science and Technology Agency).

Until the early eighties the domestic research projects aimed at catching up with the U.S. competition and technologically surpassing it. The core and major success of those endeavors was the "VLSI Project" ("Very Large Scale Integration") by MITI and Nippon Telegraph & Telephone (NTT) to develop the process technology for the 64 KB [kilobit] chip. After achieving global technological leadership in the mid-eighties, in the next phase

MITI limited its research policy activities to basic technologies or to areas that Japan's profit-oriented semiconductor firms would not cover without government initiative. MITI views its responsibility as the conception, planning and organization of long-term R&D projects entailing research risks while simultaneously holding the potential for a technological breakthrough (Fransman 1990; Okimoto 1989). In actuality there exists no cartel legislation limiting research cooperation under overall government control or even private-sector combined research. But there does exist an obligation to register with the Fair Trade Commission (FTC).

Project planning contains ambitious research goals set forth in detail, precise timetables and meticulous agreements relating to division of labor and costs. All participants have to subject themselves to outside monitoring of application of resources and efficiency of research by representatives delegated from other participating firms. Identification of the research themes is done in a presurvey of the private sector. MITI itself aspires only to the role of catalyst and strategic leader, not that of sole determining administrator. An additional function of government activity consists in signaling government's go-ahead for new technologies (Fransman 1990). Tables four and five list the most significant R&D projects of the past and the present.

Whereas in the imitation phase of the seventies domestic research projects benefited Japanese firms in catching up and moving ahead technologically, the research projects of the eighties were incapable of realizing any revolutionary breakthroughs. Frequently there was support for technological solutions that could not subsequently be implemented on the market (Bletschacher, Kloth 1992). Such criticism, however, does not impact on the core of MITI's industrial policy motivation. For it is in the nature of scientific research that results cannot be planned. By definition, R&D with a long-term focus entails research risks. From MITI's optic, short-term market success is not the decisive industrial policy goal, instead, it is the medium to long term improvement of the technological potential of Japan's semiconductor firms, stimulation of firms' commitment to pursue long-term R&D strategies and to enter into R&D risks.

The response of the private sector to MITI's R&D initiatives is not unanimously positive. MITI projects require a steep organizational and administrative cost from participants. By comparison, the NTT projects are more efficiently organized and therefore are also preferred by the firms. In many instances MITI succeeded in assembling the technologically relevant firms for a joint research project only by pressuring them or through an extensive absorption of costs. The motives for cooperation, however, can be explained not only by the huge administrative power of MITI. Since government's share, up to 50 percent, of co-financing in the projects is not exactly minor and the remaining project costs are apportioned among the participating firms, the individual company has an opportunity of carrying out attractive R&D projects at relatively low costs. Participation in a MITI project also facilitates participation in the know-how of rival firms and in projects of a more recent date, even in the technology of top western firms. On the other hand, MITI shapes up as an impartial broker controlling, as fairly as possible, the in- and outflow of know-how. One decisive reason for firms to participate in domestic research projects is often also the prestige associated with them, since participation in a MITI project in Japan constitutes proof of technological leadership.

Table 4: Japan's National Semiconductor Research Projects 1962-1994—in millions of DM

Program	Duration	Government support
FONTAC Project	1962-	n.a.
Very High Speed Computer System	1966-1971	133
DIPS-1/DIPS-2	1968-1975	394
Pattern Inf. [Information] Proc. [Processing] Systems	1971-1980	233
Mainframe Project	1972-1978	751
Software Module Project	1973-1975	24
VLSI Project (NTT)	1975-1977	246
VLSA Project (MITI)	1976-1980	378
Software Production Technology Development	1976-1981	82
Fourth Generation Computer Systems	1979-1983	194
Optical Measurement and Control Systems Project	1979-1985	165
Optoelectronic IC Programs	1981-1986	181
Future Electronic devices (FED)	1981-1990	753
Supercomputing (VHSSC)	1981-1989	274
Fifth Generation Computer Systems	1982-1991	808
Interoperational Database System	1985-1992	453

Table 4: Japan's National Semiconductor Research Projects 1962-1994—in millions of DM (Continued)

Program	Duration	Government support
Photoactive Materials	1985-1992	n.a.
Software Industrial generator and Aid (SIGMA)	1985-1994	283
TRON (32-Bit Microprocessor)	1984-1989	n.a.

Sources: BMFT [Federal Ministry for Research and Technology] (1992) and ifo research; original data in U.S. dollars, conversion at current exchange rates.

Table 5: Current Japanese Domestic Semiconductor Projects—in millions of DM

Program	Duration	Government support	Project sponsor
Real World Computing[1]	1991-2000	864	MITI
Ultimate Manipulation of Atoms and Molecules (Nanomechanism)	1992-2001	308	NEDO/ETL [New Energy and Industrial Technology Development Organization/Electrotech nical Laboratory]
Quantum Functional Devices	1991-2000	185	NEDO
Superconducting Devices and Materials	1988-1998	343	NEDO
Bioelectronics Devices	1986-1995	8.6[2]	NEDO
Nonlinear Photonics Materials	1989-1998	16.8[2]	NEDO
New Models for Software Architecture	1990-1997	8.2[2]	NEDO
Femtosecond Technology	1993-1997	1.4[2]	NEDO/ETL
Ion Engineering Center	as of 1990	n.a.	NEDO
Optoelectronic Devices	1986-1996	129	JKTC
SORTEC (Synchrotron-Lithography)	1986-1996	185	JKTC
Free electron Laser and their Industrial Application	1990-1997	98	JKTC
Coherent Light Measurement	1986-1995	55.4	JKTC
Magnetic Devices with Amorphous Metallic Cores	1988-1993	32	JKTC
Superconducting Sensor Technology concerning to SQUID [Superconducting Quantum Interference Device]	1989-1995	87	JKTC
Super-High-Speed Electronic Measurement Technology	1992-2001	92	JKTC
New Sensoring Technology by Measuring Biophotonic Phenomena	1993-1998	96	JKTC

1. Also known as "New Information Processing technologies(NIPT)," "Massively Parallel Computer Project" or as "Sixth Generation Computer Project."

2. Data only for fiscal years 1993 and 1994, respectively.

Sources: MITI, NEDO, JKTC. MITI data in yen, conversion at current exchange rates.

Addendum: Planned semiconductor projects: Bioelectronics interface, Cold-beam assisted processes, Integrated computer-aided design [CAD] environment, Quantum metric standards, Multi-modal-information environment, Information-field based technology, Advanced adaptive problem solver, Counterhazard electronics, Self-learning information-server, Super networking technology

Until the early eighties only MITI institutions[1] and NTT [Nippon Telegraph and Telephone] were supporters and organizers of industrial and technological policy for the semiconductor industry. During the eighties the technology infrastructure was systematically expanded through the development and expansion of numerous new institutions falling under MITI's administration:

—NEDO (New Energy and Industrial Technology Development Organization), established in 1980, is the financier and sponsor of high-technology research in the field of energy and industrial technologies. In combined projects, NEDO assumes 50 percent of the budget (and, in fact, up to 70 percent out of its own funds and up to 30 percent through private-sector participation). Participating firms finance the remaining 50 percent with low interest loans from the JDB or from private banks.

—In 1985, JKTC (Japan Key Technology Center) was set up with the proceeds from the partial privatization of NTT and Japan Tobacco and it is a financing institution for high technologies in the fields of electronics, new materials, biotechnology and telecommunications.

JKTC's maximum participation in R&D outlays for private-sector combined projects is 70 percent. Between 1985-1993 it expended nearly 43 billion yen (approximately [ca.] DM642 million) for such purposes. JKTC also grants low interest R&D loans to industry covering a maximum 70 percent of the total budget.[2] JKTC also oversees coordination and information responsibilities.

—The JDB grants low interest loans up to 50 percent of the investment volume for the latest technologies or pilot lines under specific conditions. The interest rate used in this case is at least one percent below the market rate.

—Since the seventies, the telecommunications firm NTT, under the administrative purview of the Ministry for Post and Telecommunications (MPT), has actively been supporting the development of industrial semiconductor technologies. NTT does not personally produce equipment and devices, acquiring them instead from one of its allied firms with which it also engages in joint development.[3] Development in the legendary "NTT labs" included prototypes of new generations of memories.[4] In Japan's research landscape, NTT projects enjoy a much higher reputation than MITI's combined projects. In the R&D center at Atsugi, in the vicinity of one of NEC's leading semiconductor laboratories, NTT maintains a semiconductor production line for testing new products and processes. Current efforts are focused on alternatives to silicon technology and the development of new semiconductor equipment (Howell, Bartlett, Davis 1992).

—Despite MITI's expansion in the field of long-term R&D, the actual sponsor of basic research in Japan is the STA [Science and Technology Agency] which expanded its activities in the eighties as Japan developed into a nation with a research- and knowledge-intensive economy. The following institutions and organizations are focused on semiconductor technology:

—The "Institute of Physical and Chemical Research (RIKEN)" as an institution for performing basic research,

—The "Japan Research and Development Corporation (JRDC)" for the dissemination of technological information and granting of loans to the private sector for R&D for the marketing of new technologies,

—The "Exploratory Research for Advanced Technology Organization (ERATO)" for organizing specific joint research projects by industry, universities and government institutes,[5]

—The "National Institute for Interdisciplinary Research (NAIR)" in Tsukuba for basic research,

—The "New Technology Corporation" awards firms development contracts and necessary loans. If marketable products result, the loans are repayable interest free.

The Monbusho (Ministry of Education, Science and Culture) holds official responsibility for university research in Japan that traditionally does not possess the same reputation as the R&D of firms. Reforms and initiatives since the mid-eighties should bring about a change of course. In the field of semiconductor research, for instance, the "Photon Factory" in Tsukuba, the "Tron Project" and the "Series Q Dataflow Architecture Project" are relevant (Howell, Bartlett, Davis 1992).

Over and above project-related and institutional R&D support, private-sector R&D in Japan's semiconductor sector enjoys tax breaks as the result of numerous measures. A tax reduction on corporate tax is guaranteed

—in the amount of 20 percent of the annual increase in R&D outlays compared with the highest past value,

—in the amount of 7 percent of costs for demonstrated R&D equipment,

—in the amount of 6 percent of R&D costs for participation in a domestic research project,

—and in the amount of 6 percent of R&D outlays by mid-size firms.

The tax rebate from such breaks may total a maximum 15 percent of the firm's total tax obligation. Additionally, 7 percent of the acquisition price of R&D equipment for basic research can be deducted from the local trade tax obligation. Eight percent of licensing revenue is tax free. There are also tax incentives for combined industrial research in the from of special write-offs and tax breaks for the acquisition of R&D facilities.

Japan has a developed system of commercial legal protection that, in many respects, is patterned on the German model. In Japan, patent protection is basically ensured on an international standard, although there are peculiarities that detract from the actual legal protection of the inventor in Japan and, as a consequence, work to the advantage of Japanese firms:[6]

—Unless Japan's strict publication requirements are taken into consideration even when applying in the homeland for establishing prior claim, the patent may be turned down in Japan.

—The three-month deadline for replying to objections to a patent application is just too short, considering the time spent on translations, on drafting replies and coordination with the patent attorney in Japan. Japan's patent office may turn down the patent application even if there is only a single objection challenging the innovation or a reply to an objection is deemed inadequate. In actuality, such a process for objections, that the Federal Republic renounced a long while back, is particularly a pain for patents that are expected to be highly profitable.

—In substantive patent law in Japan no equivalency examination, in the European sense of the term, is performed. If, for instance, in a patent that has been issued, a component comprises 20 percent of a product and a later patent application sets the percentage of that

component at 23 percent, Japan's patent office will then issue a patent for that only minimally altered invention too. In Europe and in the U.S., such a case would come under an equivalency scrutiny and the application would not be acknowledged. This regulation reduces the scope of the legal protection for patents in Japan and elicits a strategy of hedging core patents with a circle of complementary patents.

—As a result of the flood of patents and the limited patent office personnel allotted to them, the period for issuing a patent is exceedingly long, according to German companies it takes five to seven years. There is a suspicion that awarding of basic patents in particular is drawn out. The result is that imitators have a lot of time to appropriate the technology underlying the application and reacting to it before the inventor can fully exercise the rights established by the patent.[7]

—Any legal proceedings against patent infringements require the plaintiff to disclose his proprietary technology. To protect the proprietary technology from third parties, the victim, as a rule, forgoes any suit out of self-interest.

Footnotes:

1. The Agency of Industrial Science and Technology (AIST), the Electrotechnical Laboratory (ETL) and the Japan Development Bank (JDB).

2. During the project phase, that may not extend beyond five years, no interest is computed. Afterwards, repayment is at market interest rates multiplied by a factor between zero and one, depending on the commercial success of the research. In the estimation of local experts, ca. 30 percent of the projects financed with loans are likely to have lead to some successful product development. Until fiscal year 1992, JKTC approved funding for a total of 45 electronics R&D projects. By its own estimate this purportedly amounted to a loan volume of DM200 million, after currency conversion.

3. Traditionally, the self-styled NTT family, comprising the group of the four "A-Makers" (Fujitsu, Hitachi, NEC and OKI) that was expanded in the eighties by the Toshiba and Mitsubishi Electric firms. Besides these are the smaller electrical engineering firms, the so-called "B-Makers." Despite wholehearted efforts by NTT to internationalize its own acquisition and development, the market share of foreign firms remains minimal. North American companies account for 95 percent of the foreign share. Market barriers include the brief period for invitation of tenders, the Japanese language and especially the lack of an ability and a willingness by foreign (above all, European) suppliers to make steep start-up investments.

4. The 64 KB-DRAM under the VLSI project, the 256 KB-DRAM and the 16 MB-DRAM (Howell, Bartlett, Davis 1992).

5. Examples include the "Perfect Crystal Project" by Mitsubish Electric, Mitsubishi Metal, Hamamatsu Photonics and the Semiconductor Research Institute, the "Nanomechanism Project" by Nikon and the Tsukuba research Consortium, the "Bioinformation transfer Project" by Nippon Shinyaku and the Osaka Medical College, and the "Ultra-fine Particles Project" by Stanley Electric, ULVAC, and the Meijo University (Richard J. Samuels, Research Collaboration in Japan (MIT [Massachusetts Institute of Technology] Working Paper 87-02), cited in: Howell, Bartlett, Davis 1992).

6. On protection of technology in Japan see: Ernst et al. [and others] 1993.

7. An extreme example is the Texas Instruments [TI] case: on 6 February 1960, TI applied to Japan's patent office for patent protection for Japan for the integrated circuit developed in the firm's own laboratory. Approval was given on 30 October 1989.

4. Government Support for Investment and Production

Government support for investment and production in Japan's semiconductor industry occurs and has occurred on two levels, first, through tax support of investment in facilities in the branch and, second, through stimulating semiconductor consumption on the demand side.[1] Also, until the early nineties, Japan's large firms were able, generally, to refinance at low costs.

On the level of the central government there are neither financial aids nor tax breaks for the semiconductor industry. One exception to this general rule is Japan's favorable write-off regulations for semiconductor production facilities and equipment in connection with ensuring a tax free reserve. Regional support for problem regions (Hokkaido, Okinawa, former coal mining areas) has not led to the establishment of semiconductor factories in those areas. Actually, Japan's semiconductor production is concentrated in the southernmost main island of Kyushu ("Silicon Island") and in northern Japan (Tohoku) because of a number of siting advantages (efficient airports, high water quality, availability of qualified labor force).

On the prefecture and municipal levels, semiconductor firms are given various incentives to set up shop and expand. By combining corporate tax, trade tax and domicile tax, firms in Japan face a maximum tax rate of 51.64 percent (see table six). According to information from an interviewee, there is no tax relief for the semiconductor industry on the level of local taxes on profits. The tax rates for property and operating capacity taxes, however, can probably be reduced or properties made available at low prices. Because of the scarcity of industrial acreage and high real estate prices in Japan, the latter can be an effective motive for setting up shop. Presently, JDB low interest loans are no longer granted for semiconductor investments,[2] unless it involved a

foreign firm that gets appropriate special terms under Japan's import support policy (for example, Fujitsu-AMD [Advanced Micro Devices] 1994). Further support on the local level can be effected by providing energy and water at low cost or an accommodation on waste management.

The tax write-off is done according to the following rules for the time being in compliance with generally prevailing stipulations:

—Semiconductor production facilities (machinery and plants) are depreciated in five years to a residual value of 5 percent.[3] By applying the favorable degressive depreciation (optional), in the first year, it is possible for a maximum 36.9 percent of acquisition costs to be written off.

—There is a 15-year depreciation period for clean rooms. It is possible in the first year, using degressive depreciation, to account for 14 percent of acquisition costs.

—The depreciation period for buildings amounts to 45 years. A maximum 5 percent applies to the first year in degressive depreciation.

Table 6: Major Taxes Impacting Firms in Japan, by Level of Government

Level of government, type of tax	Central government	Prefectures and municipalities
Corporate Income Tax	37.5 percent	—
Enterprise Tax	—	13.2 percent (deduction from tax computation basis)
Inhabitant Tax	—	7.76 percent
Landholding Tax	0.3 percent (of value of trade)	—
Fixed Assets Tax/City Planning Tax	—	1.4 percent + 0.3 percent (of value of trade, on property and plant)

Source: KPMG

Apart from the generally prevailing depreciation system, the possibility of special write-offs combined with a tax-free reserve on the basis of specific legal stipulations afford an effective tax incentive for investments in semiconductor production equipment and facilities. The input from surveyed semiconductor firms on this issue was contradictory. The following picture emerges from the literature:

—Higher depreciation rates are provided for plant and equipment to the extent that the operational running time exceeds a period of eight hours/day and six days/week with 14 holidays/year. Given a full 100-percent use of capacity for the entire year (24 hours/day, 365 days running time) a maximum percentage of 74.5 percent of the residual value per annum is permissible (Finan, Amundsen 1992).

—In supported areas it is possible for the first year of service to apply in advance a designated amount of the depreciation value of an economic asset as a write-off. In the depreciation periods for the remaining time of service the depreciation rates again increase by equal amounts for all years. Such special depreciation rates amount to:

—30 percent for equipment and 15 percent for clean rooms in technopolis regions,

—15 percent for equipment and 8 percent for clean rooms in underdeveloped regions.

More than 70 percent of Japan's semiconductor factories are in such supported areas (Fian, Amundsen 1992; Gomi 1993).

Based on the provisions explained above, according to calculations by Finan and Amundsen the depreciation rate for semiconductor equipment amounts to 88 percent in the most favorable instance when applying the first-year's tax free reserve. In tax years two to seven, respectively, the value of the depreciation amounts to more than 100 percent and only in the eighth year does it again realize a value of 95 percent.

Lower Capital Costs for Japan's Semiconductor Manufacturers?

There is a widespread assumption that at least until the early nineties nominally lower capital costs underlay a major competitive advantage for Japanese semiconductor companies, especially in the financing of their investments in R&D and production facilities. Two phases have to be distinguished in assessing this issue.

In the initial phase, up until the lifting of the foreign exchange control law in 1980 and implementation of gradual liberalization of interest in the eighties, Japan's segmented finance and capital market system resembled that of Korea today in its structure. In that period, large Japanese companies, mostly financed by bank loans—in the presence of a scarcity of loan capital and officially set low interest rates in the segmented Japanese finance system—had privileged access to the loan capital of the leading major banks. In comparison to the U.S., at that time, based on different computations for different periods of time, the result for Japan was lower financing costs totaling between 1.6 and 6.7 percentage points. Such computations, however, do not take into account the diverse characteristics of Japan's finance system and therefore exaggerate possible differences. The reason is that the interest rate that a provider of capital grants to a company depends, among other things, on the firm's

share of company capital, the scope and quality of the relationship between the provider of the capital and the recipient of the capital (bank and keiretsu system in Japan) and the applicable balance-sheet regulations, especially when assessing assets. On all such points Japan displays characteristic peculiarities (Hilpert 1990; Kester, Luehman 1992).

Financing advantages increased for Japanese companies in a second phase along with the revaluation of the yen vis-a-vis the U.S. dollar following the New York Plaza agreement and as a result of Japan's highly expansive monetary policy to overcome the recession. The prevailing speculative overheating of the financial markets and the economy ("bubble economy") in the resulting boom[4] laid the financial groundwork for implementation of long-term R&D and investment strategies by Japan's major firms. Although even at this time Japan's interest on loans was below the international level, still, Japan's large industry's decisive capital cost advantages were in the reissuance of shares or the granting of convertible loans and debenture bonds on Euro-capital markets. In record times, capital costs were reduced to zero. The following factors, in particular, accounted for this:

—On the basis of a "Triple A-Ratings" assessment by international lending agencies, virtually all of Japan's top large corporations received the best terms on the Euromarket.

—Issuers and investors included future share earnings in the their calculation of the issuance price.

—Innovative financing lowered the effective interest burden on foreign currency loans by one to two percentage points (currency swaps).

Following the crash on Japan's stock and real-estate markets and the collapse of the speculative boom, those competitive financing advantages of Japanese corporations were canceled out. Convertible loans no longer are converted into company capital, instead they have to be repaid. According to information from local interviewees, the low capital costs of the past, however, did significantly enhance the power of Japan's semiconductor industry.

Footnotes:

1. For example, on MITI's initiative, in 1961, the "Japan Electronic Computer Corporation" (JECC) was established to promote the sale of Japanese computers. The six leading manufacturers (NEC, Toshiba, Fujitsu, Hitachi, Mitsubishi, Oki) lease their products via this channel to interested domestic customers who get low interest loans (for example, between 1961-1981: $7.25 billion) from the "Japan Development Bank." The JDB and government financial institutions for supporting mid-size businesses (Small Business Finance Corporation, People's Finance Corporation) also granted, by means of numerous other programs, low-interest loans to domestic firms for acquisition of electronic devices and equipment. The interest rate applied in this case was at least 1 percent below the market interest rate. Even until the end of March 1994, low interest loans totaling ca. DM900 billion had been granted by the JDB to the private sector for acquisition of information technology production and test equipment. At present, however, such measures for expanding demand in the semiconductor sector no longer play any role.

2. Such support occurred at least until 1985.

3. The depreciation period for semiconductor equipment (having more than 500 transistors per chip) is—unlike the general regulation for production equipment and facilities—shortened from seven to five years on the basis of cabinet resolutions to be implemented at an interval of two years respectively (EIAJ [Electronic Industries Association of Japan] information 1994).

4. The boom that lasted from early 1987 until the autumn of 1991 gave Japan's economy an unexpectedly powerful growth impetus of a real minimum 4 percent per annum with gross domestic investments respectively making the largest contributions to growth. Paralleling the high rates of economic growth and the tremendous expansion of liquidity, prices of material assets (companies, property and real estate, golf club memberships) increased speculatively. The expansion of the money supply did not result in any public inflation but only had "asset-price inflation" as a consequence. The low interests made material assets more profitable than investment in monetary assets inducing investors to go intensively into material assets. Sleeping reserves of firms quoted on the stock market, in the form of undervalued ownership of property and shares (among allied firms) sparked speculation on Japan's stock markets. The affiliation and therefore also the capital involvement in keiretsu corporate conglomerates and a mythical trust in the stable value of land on the Japanese islands constituted confidence building factors from an investor's optic while risks appeared to virtually nonexistent. Subsequently, share prices on Japan's stock markets speculatively kept ratcheting upwards with the market values of other assets. In four years the Nikkei shares index tripled (from 13,000 at year-end 1985 to nearly 39,000 at year-end 1989) (Ernst, Hilpert, Laumer 1992; Hilpert 1990).

5. Restrictions on Market Access in the Semiconductor Industry?

In the eighties, protection of Japan's domestic market against U.S. import competition constituted an effective instrument for stimulating demand in the semiconductor sector. Only under tough U.S. foreign trade policy pressure were protective foreign trade tariffs and traditional restrictions on market access gradually eliminated:

—Lifting of quantitative import restrictions by means of quotas and awarding of licenses 1974/75.

—Lifting of ban on direct investment in semiconductor sector 1974/75.[1]

—Elimination of tariff protection in two stages:

—1983, reduction from 15 percent to 4.2 percent,

—1987, reduction to 0 percent.

Currently, Japan's tariff rate on semiconductor equipment likewise amounts to 0 percent, for semiconductor materials—depending on product category—it amounts either to 0 percent or practically 0 percent. Paralleling the market opening in the semiconductor sector, tariffs and barriers to market access in consumer electronics and information technology also were done away with. At present too, the export support measures that were significant into the eighties no longer play any part (Howell, Bartlett, Davis 1992; Okimoto 1989).

At the present time, however, problems of access to the market continue to persist. The critical points involve the following areas:

1) Markets closed to suppliers because of long-term ties to suppliers and vertical integration of the consumer industries (keiretsu),

2) the government procurement system,

3) the presence of supplier cartels impacting the domestic and international markets,

4) the bilateral semiconductor agreement between Japan and the U.S.

Strategic Corporate Ties (Keiretsu)

Strategic corporate interlinkages in Japan (keiretsu) constitute effective barriers to market access for foreign firms (more accurately: for non-insider firms) generally including, therefore, also foreign semiconductor firms. Both the vertical integration of Japan's semiconductor industry with the electrical engineering firms as well as the existence of firm supplier ties by consumer firms with domestic semiconductor producers—a relationship that is often documented by capital ties or the seconding of employees—constitute effective market barriers for outsiders. Paralleling such structures on the customer side are widespread prejudices and skepticism regarding foreign suppliers (language, assumption lower quality, skepticism about supplier promptness and service). Even in the case of technological superiority or price advantages, foreign suppliers, at least at the close of the eighties, had not succeeded in getting a foot into the Japanese semiconductor market.

In the debate on economic policy the Japanese side, above all, points to the economic advantageousness of the keiretsu[2]. It is argued that trade restrictions cannot be associated with entering into long-term contractual relationships. In actuality, if the organization of the industrial division of labor in Japan is superior to the system practiced in western countries, there can be no talk of impermissible blockading of the market. Apparently even in the organization of the industrial division of labor Japanese firms have a lead analogous to the more familiar forms of business management innovations from Japan, such as "kaizen" or "lean production." In theory, at least, foreign companies are free to learn from Japanese organizational principles and develop similar systems.

Countering this line of reasoning are the complaints by managers of foreign firms in Japan about persistent systematic discriminations in effectively competing with Japanese rivals. Despite more favorable price offerings or qualitative leads, a foreign firm does not penetrate as a supplier in Japan because it is not a member of the group or it is not regarded by domestic purchasers without insider recommendation. Absent a production site in Japan or long years of proven performance, the foreign firm has very little or no opportunity to achieve acceptance as a supplier. Only if the foreign firm possesses some technology still unfamiliar in Japan is it possible by means of licensing its patents or a joint venture with a domestic partner to participate in the Japanese market. Both procedures, however, entail the risk of losing the technology as such. Since Japanese firms in western markets do not confront such difficulties, it is proper to speak of competing on an unlevel field.

Government Procurement System

In Japan, government procurement is a traditional instrument of industry policy for supporting domestic branches although because of Japan's low government quotas it enjoys only comparatively limited prestige. In the past, supplying of electronics and telecommunications products to the government and to the NTT telecommunications company constituted a secure market for Japan's information and telecommunication industry. By means of it the Japanese semiconductor industry also indirectly benefited. Only massive U.S. pressure brought about a gradual opening of Japan's procurement markets for foreign, mainly U.S., suppliers. Bilateral trade policy conflicts in the supercomputer, satellite and mobile radio product groups made for headlines. The aerospace, avionics, medical electronics and telecommunications equipment sectors also proved problematical.

Supplier Cartels in the Semiconductor Industry

MITI's initiative in establishing the "Japan Electronic Computer Corporation" (JECC) in 1961 was aimed not merely at stimulating demand and promoting sales, it also endeavored, in a far-reaching objective, to shape the structure of the market in the computer sector and to form powerful domestic firms capable of smashing IBM's supremacy on Japan's domestic market. By limiting members to six suppliers, MITI signaled which firms would be the market leaders in the growth branch of electronics. Each of the six large horizontally allied groups were represented in that exclusive club (Okimoto

1989).[3] Because of MITI's authority those firms later were given privileged access to loan capital, import licenses and technology (TI licenses) (Howell, Bartlett, Davis 1992). Subsequently, those firms in fact developed into Japan's leading electrical engineering firms and into the most import suppliers of semiconductors too, deriving from them. This group was rounded out by a handful of consumer electronics firms (Matsushita, Sony, Sanyo, Sharp, etc.). Under intense competition on Japan's internal market those firms cooperated to ward off potential foreign competitors and to work the foreign markets (Howell, Bartlett, Davis 1992).

Organizing industrial firms from the same branch by means of government influence by MITI is not an exception for the semiconductor industry, it can also be observed in other sectors. Generally, Japan's industrial culture has as a characteristic feature the interplay of cooperation and competition. Despite usually intense competition on the Japanese domestic market, mutual coordination of firms from the same branch is typical, for example, in terms of sales prices, production quantities, buildup and builddown of capacities or strategic decision making, affecting all the firms. In many instances MITI assumes overall leadership in the decision making (Johnson 1982; Johnson, Tyson, Zysman 1989; Okimoto 1989; Semiconductor Industry Association 1983). Although Japan's legislation on competition constitutes a technical barrier to cartels and to behavior limiting competition, Japan's cartel authority ("Fair Trade Council") still has acted effectively as executive thus far only in individual cases against breaches of competition.[4] The primary aim of Japan's market and competitive policy was to stimulate competition and dynamism on the markets—with no dogmatic focusing on a model. To be sure, it did succeed in this in the semiconductor industry as well as in many other branches.

The industrial collaboration on Japanese semiconductor firms has effective impacts on the Japanese domestic market and the global market. Firms' cooperation succeeded in the effort to close the domestic market to U.S. competition. At present Japan's electrical engineering firms are cooperating in their efforts to realize the expansion of the foreign market percentage to a total of 20 percent promised in the semiconductor agreement by Japan. In this context the User's Committee of Foreign Semiconductors has overall responsibility. The cartel behavior of Japan's semiconductor industry clearly manifested itself also on foreign markets.

The Bilateral Semiconductor Agreement Between Japan and the U.S.

Despite intensive efforts by foreign semiconductor firms and continued pressure by U.S. foreign trade policy to open the market, until the end of the eighties, the market penetration of foreign suppliers remained marginal. Only the bilateral pact of a semiconductor agreement between the U.S. and Japan brought about any improvement from the U.S. optic. Serious efforts by MITI to expand the U.S. market share, Japanese-American contacts on the association and corporate levels and last [but] not least, intensive efforts by U.S. producers to realize a greater market presence in Japan and to improve their product quality resulted in increasing foreign market shares.

While in the original semiconductor agreement there was still mention only of U.S. companies, the second agreement expressly applies to foreign firms. To that extent, it is no longer possible to strictly speak of discrimination. In fact, even European and Asian suppliers profited from the agreement and their situation has improved vis-a-vis the status quo ante. Still, the bilateralness of the agreement automatically discriminates against third country suppliers. Only U.S. firms are succeeding, by means of the agreement, of breaking into firmly established relationships, as it were with a crowbar, and achieving an insider status in the Japanese system so as to participate in the dynamism and innovation of the Japanese market.

Footnotes:

1. A lone exception was Texas Instruments that in a joint venture with Sony beginning in 1968, produced, 100 percent on its own, semiconductors for the Japanese market starting in 1972. TI was given approval in compensation for the lifting of what boded to be a successful suit with the U.S. patent court against Japanese importers of pocket calculators and televisions to the detriment of the basic TI patent (Howell, Bartlett, Davis 1992).
2. For a thorough description of Japan's keiretsu, see: Hilpert (1994).
3. Mitsubishi Electric (Mitsubishi group), NEC (Sumitomo group), Toshiba (Mitsui group), Fujitsu (Dai-Ichi-Kangyo group, Oki (Fuyo group) and Hitachi (member of Fuyo, Dai-Ichi-Kangyo and Sanwa).
4. The sharpening of Japan's legislation on competition in response to U.S. pressure, above all, however, the growing sensitivity of the Japanese public to the concentration of economic power, is likely to bring about some change in the future.

6. Other Measures

One major problem for Japan's semiconductor industry lies in the shortage of electrical engineers trained for systems integration and software development. To overcome this stranglehold, MITI is mulling the establishment on its own initiative of a "Software Factory" for university training in that area. Such a measure would, however, mean an intrusion into Monbusho's areas of jurisdiction.

Foreign competitors charge Japanese semiconductor firms of selling below cost (dumping) and in general of engaging in a coordinated strategy of aggressive market conquest and driving out of foreign competition. Absent

accurate knowledge of relevant production costs, especially the "Yield Curve" realized for ICs, this charge can neither be absolutely confirmed nor refuted. The competitive practices of Japanese suppliers of memory products (above all, DRAMs) on the U.S. market between 1981-1986 do seem anecdotally to confirm such charges (Howell, Bartlett, Davis 1992):

—Existence of aggressive price competition in the mature phases of 16 KB and 64 KB DRAM generations (1981-82, 1984-85),

—Existence of Hitachi's notorious "10 Percent Memo" ordering the individual chip vendor to underbid any counter offer by 10 percent,

—Agreement of Japanese producers, under a "5 Company Rule," to each sell aggressively only to internally designated U.S. client firms.

Also supporting the thesis of dumping and cartel behavior is the tough competitive climate in Japan where the use of market power and corporate power play is typical and as a rule is not constrained by the government executive. Business practices common on Japan's domestic market are also applied abroad. The thesis of technology-driving DRAM and the awareness of the need to realize advantages of scale from the learning curve provided firms with the motivation for such aggressive conduct. Also not to be overlooked is the economic calculation of Japanese semiconductor firms that were counting on future cartel profits.

Countering such arguments is the fact that Japan's semiconductor producers did derive obvious competitive leads on the process and product levels and the market successes that were realized can be well explained on the basis of the same. Competitors driven from the field base their downfall on their rivals' unfair methods. Moreover, since on the Japanese market competing to drive the other fellow off is not atypical (however, it may encounter the resistance of firms with comparable capital power), the charge of dumping is not understandable from Japan's point of view.

The Japanese-American semiconductor agreements explicitly tackled the dumping issue and demanded an orientation on production costs from Japanese producers when setting prices. In the second agreement (1991-1996), the control mechanisms on dumping are less sharply drafted and this might indicate a change of behavior. That dumping behavior in Japan is not a thing of the past, however, is indicated by remarks from local observers about a current example. In the gallium arsenide wafer segment, Sumitomo Electric used ruinous price competition to drive rivals Shin-Etsu and Wacker out of the market. Despite different notions on restrictions on competition and the way competition works in general, however, there is virtually no contesting the fact that the market and competitive behavior of Japanese firms that contrast with standards prevalent in the West not in their quality but in their toughness and intensity, will necessarily lead to conflicts.

A second charge often voiced by foreigners in the West against Japan's semiconductor industry alleges boycotting and refusal to deliver. Two factual instances are adduced in this context:

1) The refusal to deliver latest-generation ICs in times of tight supply to non-Japanese, overseas chip customers,

2) The refusal to deliver equipment and devices for producing technologically advanced semiconductor products to non-Japanese, overseas semiconductor manufacturers and refusal jointly to implement any relevant development.

That such behavior by Japanese suppliers does occur at least occasionally appears to be undisputed on the basis of experiences during he 1987-1989 period when DRAM was in short supply and according to remarks by the impacted European and American companies. At present, as a result of the recession on the Japanese market, however, there are apparently no problems of this sort. It may be inferred from this that refusals to deliver in the past primarily reflected tight-supply situations on specific product markets and only secondarily were they based on strategic considerations by Japanese firms. The long-term, strategic supplier ties in Japan in the context of keiretsu relationships underlie preferred delivery to Japanese firms in times of tight supply and maintaining market balance not absolutely via pricing but frequently via discriminatory allocation of quantities. In tight supply situations, typically, hierarchical priorities depending on length, scope and importance of business relationships determine delivery behavior.

7. Assessments

The development of a globally competitive semiconductor industry in Japan was supported and accompanied by a comprehensive industrial policy based on long-term planning and strategic action. Underlying the branch's success was the actual closure of the domestic market (semiconductor and systems segment) to the U.S. competition, that reaches into the present. Of major importance, too, was the acceleration of the process of catching up technologically, using the instrument of domestic R&D projects and the cr...ibility of signals from the government that steadily influenced corporate behavior. In addition to these there were phase-by-phase favorable financing terms.

The obvious effectiveness of the industrial policy for the semiconductor industry in Japan rests on unique foundations: the uncontested overall leadership of industrial policy planning by a single authority (MITI), the existence of a large, receptive domestic market and the interlinkage of private sector and government and the industrial policy consensus resulting therefrom.

Notwithstanding the important contribution of industrial policy to the development of a powerful semiconductor industry, originally two other factors probably accounted for the success:

—The demand pull from consumer electronics and information technology.

—Japanese firms' dynamism and ability to innovate coupled with intensive and tough competition on the domestic market.

On the basis of those two factors and owing to the global positioning and technological competence of the semiconductor firms, the Japanese branch is likely even in the future to play a leading role in global competition—despite the brief collapse of demand on Japan's domestic market caused by the recession.

There are risks for Japan's semiconductor industry in the foreign economic area. Access to the markets of the industrial countries and continued technological cooperation with U.S. firms calls for extensive compliance with American demands on Japan's part. MITI will have a central role in this context:

—Allocating export quotas (maximum quantities),

—Allocating import quotas (minimum quantities),

—Moderating pricing arrangements and decisions on capacity,

—Representing the interests of Japan's semiconductor industry vis-a-vis U.S. economic policy and influencing the formation of opinion abroad.

An unwanted result of the Japanese-U.S. foreign trade conflict therefore consists in the enhancement of MITI's role—counter to the general trends towards liberalization and deregulation in Japan.

Bibliography

Bletschacher, G.; Klodt, H. (1992), Strategische Handels- und Industriepolitik. Theoretische Grundlagen, Branchenanalysen und wettbewerbspolitische Implikationen [Strategic Trade and Industrial Policy. Theoretical Bases, Branch Analyses and Competitive Policy Implications]. Kieler Studien Nr. 244. Tuebingen.

Bundesministerium fuer Forschung und Technologie (Hrsg.) [Federal Ministry for Research and Technology (editor)] (1992a), Wettbewerbsverzerrungen und staatliche Foerderung der Mikroelektronik im internationalen Vergleich - Fakten und Zahlen im Ueberblick. [Distortions of Competition and Government Support for Microelectronics in an International Context - Facts and Figures Surveyed]. Bonn.

Bundesministerium fuer Forschung und Technologie (Hrsg.) (1993a), Informationstechnik und Mikroelektronik. Ein forschungs- und industriepolitischer Laendervergleich [Information Technology and Research and Industrial Policy Comparison by Country]. Bonn.

Dodwell Marketing Consultants, Ed. (1993), The Structure of the Japanese Electronics Industry, 3rd. Edition. Tokyo.

Ernst, A.: Hild, R.: Hilpert, H. G.; Martsch, S. (1993), Technologieschutz in Japan - Strategien fuer Unternehmenskooperationen. ifo studien zur japanforschung [Technology Protection in Japan - Strategies for Corporate Cooperations. Ifo Studies on Japanese Research] Nr. 9. Munich.

Ernst, A.; Hilpert, H.G.; Laumer, H. (1993), Japans Wirtschaft im strukturellen Wandel: Wettbewerbsposition, Ungleichgewichte, Reformbedarf, in: Japan und Europa: Getrennte Welten? Schriften des Forschungsinstitutes der Deutschen Gesellschaft fuer Auswaertige Politik [Japans Economy in Structural Change: Competitive Position, Disequilibriums, Need for Reform, in: Japan and Europe: Worlds Apart? Documents of the German Society for Foreign Policys Research Institute]. Pp. 51-84. Frankfurt am Main [a.M.]

Finan, W. F.; Amundsen, Ch. (1992), Analysis of the Relative Economic Benefits of Tax Depreciation Policies for Semiconductor Equipment and Facilities in the United States and Japan. Washington D.C.

Fransman, M. (1990), The Market and Beyond. Cooperation and Competition in Information Technology Development in the Japanese System. Cambridge.

Gomi, Y. (1993), Guide to Japanese Taxes 1993-94. Tokyo.

Hilpert, H. G. (1990), Hintergruende der japanischen Yen- und Aktienbaisse, in: ifo Schnelldienst [Background to the fall of the Japanese yen and stocks, in: ifo Express Service] 25/1990, pp. 12-16. Munich.

Hilpert, H. G. (1993), Japanische Industriepolitik: Grundlagen, Traeger, Mechanismen [Japanese Industrial Policy: Bases, Platforms, Mechanisms], in: ifo Schnelldienst 17-18/1993: S. 7-22. Munich.

Hilpert, H. G. (1994), Strategische Unternehmensverflechtungen in Japan (Keiretsu) und ihre Relevanz fuer den Maschinenbau und die Halbleiterindustrie [Strategic Corporate Ties in Japan (keiretsu) and Their Relevance for Machine Building and the Semiconductor Industry] , in: ifo Schnelldienst 17-18/1993. Pp. 7-22. Munich

Howell, T. R., Bartlett, B. L; Davis, W. (1992), Creating Advantage. Semiconductors and Government Industrial Policy in the 1990s. Dewy Ballantine.

Johnson, Ch. (1982), MITI and the Japanese Miracle. The Growth of Industrial Policy, 1925-1975. Stanford.

Johnson, Ch.; Tyson, L. DA.; Zysman, J. (Eds.) 1989), Politics and Productivity, How Japan's Development Strategy Works, A Research Project of the Berkeley Roundtable on the International Economy. Berkeley.

Kester, W. C.; Luehrman, T. A. (1992), The Myth of Japan's Low-Cost Capital, in: Harvard Business Review, May-June, Pp. 130-138. Boston.

Ministry of International Trade and Industry: Policies on Promotion of Industrial Technology for Fiscal 1991 by Ministry of International Trade and Industry. Tokyo.

Okimoto, D.I. (1989), Between MITI and the Market. Japanese Industrial Policy for High Technology. Stanford.

Semiconductor Industry Association, Ed. (1983), The Effect of Government Targeting on World Semiconductor Competition, A Case History of Japanese Industrial Strategy and Its Costs for America. Washington, D. C.

Shin, H. (1992), Japan's Semiconductor Industry at a Crossroads, in: NRI Quarterly, Summer 1992. Ed.: Nomura Research Institute, Pp. 46-65. Tokyo.

Thyson, L. D'A. (1992), Who's Bashing Whom? Trade Conflict in High-Technology Industries. Washington, D. C.

U. S. International Trade Commission (Ed.) (1993), Industry and Trade Summary. Semiconductors. USITC Publication 2708, Washington, D. C.

Watanabe Ch.; Honda, Y. (1992a), Inducing Power of Japanese Technological Innovation—Mechanisms of Japan's Industrial Science and Technology Policy, in: Japan and the World Economy, Vol. 3, No. 4, April 1992, Pp. 361-390. New York.

Watanabe, Ch.; Honda, Y.(1992b), Japanese Industrial Science & Technology Policy in the 1990s. MITIs Role at a Turning Point, in: Japan and the World Economy, Vol. 4, No. 1, May 1992, Pp. 47-67. New York.

Wattenberg, U. (1992), Staat und Industrieforschung [Government and Industrial Research], in: Manfred Pohl (Hrsg.), Japan 1991/92, Politik und Wirtschaft. Institut fuer Asienkunde [Government and Private Sector. Institute for Asia Studies], Pp. 287-304. Hamburg.

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Ministry of International Trade and Industry (Mr. Nakayama)

Mitsubishi Electric Corporation (Mr. Michiyo Shindo, Mr. Hirotoshi Ando)

Mitsubishi Research Institute (Mr. Keiichiro Takimoto, Mr. Masahiro Akutsu)

National Semiconductor (Mr. Noboru Yamada)

NEC (Mr. Yuji Gotou)

Nomura Research Institute (Mr. Hitoshi Shin)

OECD [Organization for Economic Cooperation and Development] (Mr. Graham Vickery, Mr. Makoto Sumita)

Sakura Research Institute (Mr. Takenori Kuroda)

Siemens, Tokyo (Dr. Hermann Rodler)

Telekom, Tokyo (Herr Paul Kuhn)

The Industrial Bank of Japan (Mr. Kyoshi Aikawa, Mr. Shunichi Hiraki)

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[passages omitted, pp 151-189 follow]

KOREA

7.1 Korea's Semiconductor Industry

In 1993 Korea's semiconductor industry realized a production volume totaling nearly DM15 billion, equivalent to a global market share of more than 10 percent (cf. [compare] table 7.1)[1] It therefore occupied third place worldwide behind the U.S. and Japan. Since ca. 80 percent of Korea's production goes into exports, Korea has, at the same time, become an important co-player on the semiconductor market. This success rests on a single product, the DRAM memory chip, with which Korean suppliers have, in the meantime, seized the initiative. Occupying fourth and sixth places in 1993 behind uncontested global market leader Samsung were the Hyundai and Goldstar firms. Those three firms were among the original supplier of 16-MB generation DRAMs. On the basis of enormous investments they currently possess the greatest capabilities and the latest, probably even the most efficient facilities. At present DRAMs are the major export product of Korea's entire electrical engineering industry that, in turn, is the country's most important export branch. In the nineties, suppliers from Korea are likely to keep expanding their leading position in memory chips and continue gaining market shares. Moreover, they are endeavoring to diversify their product palette. To achieve this they are primarily offering the new flash chips and the ASIC segment.

Chip assembly on the order of foreign manufacturers traditionally represents a second successful specialization of Korea's semiconductor industry. Anam, the most successful of nearly 10 Korean firms in this segment, has advanced to global market leader. Through acquisitions in the U.S., the Philippines and Scotland, it has safeguarded its activities on all markets of the triad. A third leg of Korea's semiconductor is based on supplying the domestic electrical engineering and telecommunications industry with diodes, transistors and ICs.

Table 7.1: Production and Export of Korea's Semiconductor Industry 1986-1993—in Millions of DM, average annual growth rate in percent

Year	Production	Exports
1991	10,627	9,402
1992	11,882	10,611
1993	14,656	11,746
Growth rates 1986-1993	25.6	23.2

Source: Korean Development Bank

From the viewpoint of Korean firms perhaps the most important task for swift development of an independent semiconductor industry was and is guaranteeing a steady transfer of technology from abroad. To do this they resort to a grab-bag of measures:

—Licensing abroad,

—Learning from joint production with a foreign joint-partner venture in Korea, OEM [Original Equipment Manufacturer] production on order of foreign semiconductor producers,

—Establishment of R&D centers in Silicon Valley, acquisition of high-tech firms in the U.S.,

—Hiring of Korean engineers having theoretical training and job experience in the U.S. or in Japan,

—Technological alliances with foreign firms (Bloom 1992).

Despite all successes, Korea's semiconductor industry still lacks technological breadth. Its weaknesses in all non-memory products are a mirror image of Korea's competitive strength in DRAMs. Imports account for 90 percent of the domestic market's supply of logic chips, for semiconductor equipment (80 percent) and materials (40 percent) the import rates are similarly high.[2] Over the medium term, closing the still considerable technological gap can at best be expected in the equipment sector where Korea is pursuing a plant set-up and technology policy.

The three top semiconductor suppliers, Samsung, Hyundai and Goldstar are firm components of the three similarly named corporate conglomerates ("chaebols")[3] and as a result have access to an extensive systems market inside the concerns. Chaebol affiliation, above all, provides the firms with the ability to mobilize external and internal resources and apply them in concentrated fashion on a single goal. On the basis of reciprocal share ownership the group share[4] constantly prevails in the affiliated chaebol firms and within the holding company the founding family's share dominates.

Footnotes:

1. Korean data that clearly turns out to be higher than international production statistics, according to Dataquest. The difference is possibly explainable by the not inconsiderable original equipment manufacturer [OEM] production of Korean producers or as a result of differing product demarcations.

2. Data from Korean Development Bank.

3. Korea's economy, even more so than Japan's, is shaped by the dominance of large corporate groups. The five largest chaebols (Samsung, Hyundai, Goldstar, Daewoo and Sunkyong) held a ca. 20-percent share of the entire domestic net product. Up until the early eighties the chaebols were systematically privileged by government economic policy since they constituted the ideal medium for practical implementation the administration's economic and social policy goals. During the eighties, as Korea's economy was liberalized, the chaebols increasingly acquired decision-making latitude that they were able to capitalize on for exaggerated growth. Simultaneously, however, there was an increase in antagonism and power struggles between the government and the private sector. Even quite recently the controversies have grown sharper (Sakong 1993).

4. On average the group share at Samsung amounts to 53.2 percent, at Hyundai, 67.8 percent and at Goldstar, 38.3 percent (Taniura 1993).

7.2 Economic Policy Philosophy

Over the past 30 years South Korea has managed to catapult itself from a backwards rural nation to the standing of "newly industrialized nation"—without being specially blessed with natural resources and despite constantly high burdens from defense outlays. This remarkable success would not have been possible with the active and shaping role of an authoritarian government that transferred its own military structures to the country's society and its economy. The forced establishment of production capabilities, the rapid development of human capital and the speedy buildup of an industrial infrastructure was consistently pushed forward until the end of the eighties by the firm hand of a traditional development-based dictatorship.

In the process of catching up industrially, Korea oriented itself both industrially and methodologically on the Japanese model more closely than any other country—because of its intimate acquaintance with its neighboring country and common basic social values shaped by

Confucianism.[1] In Korea's government-controlled market economy based on indicative five-year plans, the export and growth-oriented economic policy protected selected sectors and firms until they achieved global competitiveness. Using this strategy, Korean industry achieved success in rapid succession in the textile, shipbuilding, steel, automotive and consumer electronics branches and most recently in the memory chips sector (DRAMs, static random access memories [SRAMs]).

As Korea understands it, "industrial targeting" requires an intensive regulation and control on the microeconomic level that extends even to the details. Until the late eighties, industrial policy was conducted by means of government wage fixing, systematic control and stimulation of loan financed investments in desired sectors and skillful foreign trade support. On the basis of educational protection and import substitution in the emerging phase of a branch, exports were systematically supported in the phase of increasing competitiveness. This strategy was bolstered until about 1988 by a systematic undervaluation of the won and encouragement of technology transfer from abroad.

As early as the eighties foreign counterreactions, sensitized by the example of Japan, but, above all, pressure for reform emerging from the domestic economy (driven by strikes, drastic wage increases; demand for greater economic efficiency and transparency) forced a change of course in economic policy countering this basic pattern of industrial policy. The seventh five-year plan (1993-1997) and the economic policy program of the new administration of Kim Yung-Sam (February 1993) have put their priorities unambiguously in the areas of opening the market, liberalization, deregulation, support for mid-size industry, battling unfair competition and curbing the economic of the chaebols. At present industrial policy is generally focused on technology-intensive branches of the economy. Simultaneously it should be remarked that support for microelectronics in Korea displays pronounced peculiarities, for example, foreign direct investments in this sector have been deliberately encouraged because of the technology transfer associated with them.

The emergence of Korea's semiconductor industry goes back to direct investments by U.S. producers. Since the sixties Korea has afforded them a cost effective assembly site. Independent domestic Korean producers in the early eighties still limited themselves to the production of technologically simple transistors and diodes for domestic consumer electronics or for mere assembly to order. Then government industrial policy, with an eye on the domestic internal market, for the first time tackling the electrical engineering industry in the fourth five-year plan (1976-1980), pursued a strategy of import substitution. By developing advanced transistor plus small and medium integration, the products needed by domestic industry were to be developed and Korea's semiconductor gradually achieved global competitiveness.

Countering this rather conservative government planning, Samsung, in a corporate top-down decision in 1983, made its own strategic mark with a bold strategy of immediately launching into very large scale integration (64 KB at the time). By concentrating on DRAMs, that make up the largest market volumes and seemed to be best suited as standard products for learning process technology, Samsung spotted comparative advantages for itself and hoped to get to the top globally as quickly as possible. Hyundai, and somewhat later, Goldstar, also decided to quickly launch into the market, following pioneering Samsung, via the DRAM segment and focused the group's investment capital accordingly. To be sure, Samsung, Hyundai and Goldstar were only able to take on the risk associated with this research venture because, in the event of a failure, the chaebols could count on government aid verging on a total assets guarantee.

Still, the risk associated with this step was considerable since in the developing country that Korea was at that time, there were practically no qualified engineers or the technology available for DRAM production, although the sale of the memory products was focused on the cyclical global market. Production of their own independent memory chip production therefore became an industrial priority for Korea's three leading chaebols.[2] Government industrial policy followed this thrust with various support measures (R&D subsidies, tax breaks).

Even in the future the semiconductor will occupy a high position in Korea's industry policy support. It occupies a central position in all ongoing industrial policy planning with its occasional overlaps. There are hints of a stronger position by the central authorities in technology and industrial policy planning (Shin, Kim 1994):

—In the seven-year high-tech plan (1990-1996) microelectronics constitutes the main thrust for support. On the product level, memory chip integration is to pushed ahead to the giga-range. There are also efforts for diversification in the ASIC segment and development of an efficient offshore equipment and materials industry (BfAI [Federal Office for Foreign Trade Information] 1990; Howell, Bartlett, Davis 1992).

—Presently, microelectronics counts as a so-called "G7 sector." In keeping with the G7 project of the "Economic Planning Board" that has overall responsibility for economic policy, by the year 2001, Korea is to get caught up to the level of development in the G7 industrial countries in 12 focal sectors [3](DKIHK [expansion not given] 1994).

—Paralleling the longer-term G7 vision, the seventh five-year plan (1993-1997) also names the semiconductor branch as one of 15 selected key industries of Korea that are to be supported by means of joint research, subsidizing of private R&D expenditures, tax relief measures and government procurement. There is provision, for instance, for high government investments for the development of an information infrastructure. It is noteworthy that the key sectors also include important industries with semiconductor

applications such as office electronics, home electronics, automobile manufacturing, machine tools, factory automation and aerospace (DKIHK 1994).

In Korea, government interventions leading to distortions of global competition are realized in the areas of R&D, investment, production and market access. In this context, however, an important proviso applies to industrial policy agents of the administration and industry: conflicts with foreign trade partners, the U.S. in particular, are to be avoided. Access to the markets of industrial countries is central to the success of the chosen DRAM strategy. With Korean development strategy concentrating on a single export product, DRAMs, and depending on foreign technology, foreign trade constitutes an exposed flank in the adopted industrial policy strategy. For this reason support activities are mostly realized subtly and indirectly. There is generally minimal support transparency. The main thrust of monetary support is in the R&D area. According to statements by the experts who were quizzed, the most effective support of Korea's semiconductor industry is realized by means of low-interest or interest-free capital made available for R&D or for investments in production facilities—a support activity that is also available for other high-tech sectors.[4]

Footnotes:

1. The following description of Korea's industrial policy is oriented on: Amsden (1990), Caiden, Kim (1990), Sakong (1993).
2. For the chronology see Hong (1992) and Seo's Case-Study (1993). Another view of the interaction between industry and government in the early phase of Korea's semiconductor industry is represented by: Amsden (1990) and Howell, Bartlett, Davis (1992).
3. They comprise the following sectors: semiconductors, new materials, automotive, biotechnology, environmental technology, new energies, ISDN [Integrated Services Digital Network], HDTV [High-Definition TV], pharmaceuticals and agrochemistry, production automation, nuclear technology, aerospace.
4. Section 7.4 has more detail on this: Investment and Production Support.

7.3 R&D Support

In the process of catching up industrially and in the transfer of technology from overseas, Korean firms received active support on various levels from the government by virtue of legal regulations and by means of administrative interventions.

In this association, the most important is likely to be the **support of joint ventures between foreign and Korean firms**. In view of the training of domestic specialized labor, the return of Korean engineers to their homeland and the import of technology hardware that go along with this, Korean-foreign semiconductor joint ventures constitute what are likely the most important lines of technology transfer (Bloom 1992). Support for the setting up of net product intensive industries is a quite legitimate instrument of economic policy. From a foreign perspective, however, discrimination results from direct government interventions in corporations' freedom of choice or in the non-physical ownership rights of the investor. Because of tariff and nontariff barriers to market access, direct investment or joint-venture production is often the only possibility for participation in the Korean semiconductor market.[1] Even if there is generally no formal joint-venture obligation, as in the semiconductor branches or investment in special export production zones, foreign investors are systematically pressured by government authorities into a joint venture with a Korean firm, for example, if the investor needs approvals from government authorities.[2] If a joint-venture does result and the production facilities are installed in Korea, the investor is generally pressured by government authorities and the Korean partner, over and above the contractually agreed regulations, to divulge the technology. On the basis of this strategy a domestic company may get access to advanced semiconductor technology that it can capitalize on concurrently with the joint venture (Bloom 1992). Moreover, foreign investors who have divulged their proprietary technology to government authorities for granting of approval, have to expect that Korean firms will be able to get a glimpse of it. For example, in the application of chemical processes, the Korean labor ministry requires the specifications of the chemicals being used. After two years, the ministry reserves the right to pass on the technical knowledge (DKIHK 1994).

In the semiconductor sector in Korea, private sector R&D is financially supported and afforded tax breaks through numerous measures:

—The semiconductor industry is granted direct R&D subsidies. The exact scope of the awarded subsidies could not be ascertained.

—The government participates via financing and payments in kind in the framework of domestic projects for joint semiconductor research (see below).

—By means of "policy loans" the firms get low-interest capital.

—Private sector semiconductor technology R&D enjoys various tax breaks:[3]

—Up to 4 percent of each fiscal year's gross proceeds can be applied tax-free to the reserves for technological developments.

—10 percent of R&D outlays, 10 percent of outlays for advanced training institutes for technology, and under specific circumstances and additional 10 percent are deductible when determining corporate taxes.

—Firms with in-house R&D institutes can depreciate them in a special write-off total 90 percent or get an 8-percent rebate of corporate tax indebtedness (optional) (DKIHK 1993).

Development of government institutes for industrial research started in the seventies. Their primary purpose was product development for domestic industry. Their task is also to stimulate more private sector R&D and to encourage Korean engineers to return to their homeland. The institutes are bound by the directives of the ministries and oversight authorities which is supposed to facilitate implementation of industrial policy projects. Two government institutes, above all, have relevance for the semiconductor industry:

1) The "Korea Advanced Institute for Science and Technology (KAIST)" under the jurisdiction of the research ministry carries out basic research and is a training center for electrical engineers with their engineering school diplomas.

2) The "Electronics and Telecommunication Research Institute (ETRI)" is responsible for industrial semiconductor research that falls under the administration of government telecommunications authorities and is also financed by them. Surpluses from Korea's telecommunications traffic are applied towards that. In ETRI, product developments are carried out in cooperation with firms with the semiconductor sector alongside consumer electronics and telecommunications constituting the main thrust. ETRI organizes Korea's joint research in the precompetitive area.

There also exists a number of more nearly applied government semiconductor R&D institutes that do not engage less in product development and more in training or support for mid-size industry, for example, institutes in the science city of Taedok, in the national university of Seoul and several other universities (BfAI 1990; Howell, Bartlett, Davis 1992).

By means of research projects implemented jointly by industry and government under the overall leadership of ETRI, there is an effort to accelerate the development of technologies for marketable export products and to avoid duplication of R&D expenditures. After the joint development of a prototype, the participating firms carry out further product developments separately from one another and set up their own production lines. In Korea's national semiconductor research projects, under the overall leadership of ETRI, each of the most advanced stages in the integration of DRAM memory chips was realized and specific semiconductor products developed to market readiness (see tables 7.2 and 7.3). In Korea the national semiconductor projects are deemed necessary to be able effectively to counter the "technological blocking" of the established industrial nations. Government support is expressed not merely in the indicated amount of financing in each of the research projects. The firms also receive interest-free or low-interest research loans under the projects. Only in the case of successfully concluded product development do the loans have to be repaid. In Korea there are no competitive policy restrictions on joint research by firms in the same branch. Instead, unlike product sectors, limited monopolies are encouraged, for example, through a utilization monopoly of limited duration for new product development or through concentration of support funding on a single supplier. This is how even pioneer Samsung was preferred over imitators Hyundai and Goldstar in DRAM support. The reason for this method of operating is increased support productivity and efficiency of allocation (Bloom 1992; Wakabayashi, Sumita 1993).

Table 7.2: ETRI Joint Research Projects in the Semiconductor Industry 1987-1990—in millions of DM

Project	Duration	Participating Firms	Government financing
ICs for motor vehicles	7/87-6/89	Daewoo, Korea Electr.	8.6
Thin-film transistors	7/87-6/89	Daewoo, Goldstar	8.6
ICs for digital video	10/87-9/89	Daewoo, Goldstar	8.6
Gallium arsenide ICs	10/87-9/89	Korea Elect., Goldstar	6.6
Acoustic wave filter	3/88-6/90	Daewoo, n.a.	10.0
4-gigahertz [GHz] high-frequency [HF] transistors	1/88-6/90	Daewoo, Korea Electr.	8.9
2-chip video cassette recorder [VCR] chip set	1/88-12/90	Daewoo, Korea Electr.	9.7
32 bit PC chip set	1/88-12/90	Daewoo, Hyundai, Samsung	9.7
VLSI laser system	1/89-2/90	Dongil, Oyang Science	14.8
Other projects (excluding the DRAM projects)			302
	1987-1990		388

Source: ETRI; conversion at current exchange rates.

Table 7.3: Korea's Domestic Semiconductor Research Projects for Development of DRAM Memory Chips and Financing of Them 1986-1996—in millions of DM

Year[1]	Government	Industry	Total project costs	Project
1986	49	44	93	4 MB DRAMs (8/86-3/89)
1987	44	26	70	
1988	24	20	44	
Σ 1986-88	117	90	207	
1989	56	101	157	16/64 MB DRAMs (4/89-3/93)
1990	53	87	140	
1991	39	43	82	
1992	30	44	74	
Σ 1989-1992	178	275	453	
Σ 1993-1997[2]	187	213	400	256 MB DRAMs (beginning: 12/93)

1. Fiscal year, from ¼ to 31/3 of the following year, respectively.

2. Currently planned outlays for the project. Project costs are likely altogether to total 500 billion won (ca. DM1 billion).

Sources: MOTIE [Ministry for International Trade, Industry and Energy], Korean Semiconductor Research Association, Seo (1993), press releases; ifo.

Only the changes in Korea's patent law in 1987 responding to foreign pressure and the projected improvement of patent protection for chip designs for the current year, 1994, will lay the technical groundwork for any effective protection for technology in Korea.[4] The possibilities of pursuing legal protection for patent infringements in the court system, however, remain slight for impacted foreign firms in Korean legal practice:

—Until 1987 the target of patent protection aimed not at the product itself but at the process. In that way it was possible for imitators, without patent infringement, to produce the same produce using a slightly modified production process (DIHKJ 1989).

—By means of the "compulsory licensing" instrument it is possible for domestic companies in Korea to capitalize on patents even against the will of the patent holder and for low, legally established licensing fees (DKIHK 1994). Since 1987 the allocation of compulsory licenses has been restricted to patents that constitute a significant further technological development, although until the "Semiconductor Chip Protection Law" (planned for 1994) takes effect, it is still possible for chip designs.

It has been possible for Korean firms (Samsung, Daewoo) to resort to low-interest government loans for the development of their own R&D centers in Silicon Valley or the acquisition of U.S. semiconductor companies. The Ministry for Research and Technology has made available to all interested firms a list of Korean microelectronics engineers overseas (Bloom 1992).

Footnotes:

1. In individual instances, special bans on imports were enacted to induce a joint venture in a product segment.

2. For approval of the investment proper, for the associated acquisition of property, for foreign exchange transactions, for the import of necessary plant equipment and, above all, for granting of tax incentives in qualifying as a high-tech investment.

3. Such tax breaks apply to all proven technologically intensive branches of the economy, they are not limited to the semiconductor industry.

4. Korean firms are charged with capitalizing on foreign patents even without a licensing agreement. In 1987, Samsung was subsequently sentenced by the U.S. "International Trade Commission" to compensate Texas Instruments for patent infringement in the form of a licensing royalty totaling altogether nearly $100 million. A licensing dispute between Samsung and Advanced Micro Devices was settled out of court in 1990 (Mody 1991; Howell, Bartlett, Davis 1992).

7.4 Production and Investment Support

The most effective investment and production support in the semiconductor industry is done by means of reduction of capital costs for the firms. This is done under the special conditions of Korea's financial system.

At their core, Korea's monetary and capital markets are characterized by a paradox: despite interests that are too low and running counter to the market (surplus demand for capital), Korea's interest rate level is higher than abroad.[1] On the whole, Korea's real interest level is quite high.[2] For example, in early 1994, the critical short-term interest rate for borrowing was above 20 percent (with an inflation rate of 6 percent) for the majority of Korean firms, the interest rate for long-term loans (5-20 years duration), 12-14 percent, and the rate for the highly coveted short-term "policy loans," 4-5 percent. There

are a number of special government development funds for providing cheap capital: the "National Investment Fund" (NIF), the "Korean Technology Advancement Corporation" (KTAC), and the "High-Tech Industry Promotion Fund." Theoretically, any bank can provide interest-free or low-interest loans, but it is the development bank ("Korean Development Bank") in particular that plays an exception role because of its liberally allocated tranches and its favorable terms. Because the system is minimally transparent it is not possible to realize accurate quantification of the funds plowed into the semiconductor industry in this manner.

Industrial policy plans supply one clue. According to the seven-year high-tech plan, government support funding for semiconductor product development are projected at a total of ca. DM3 billion, and at a total of ca. DM90 million for the semiconductor equipment industry (Howell, Bartlett, Davis 1992). Under the G7 program, the semiconductor industry is to receive DM235 million.

Through financing by means of "policy loans" it was possible in the period 1983-1991 to realize an interest rate advantage of 8-15 percent. The interest rate advantage for long-term capital borrowing, however, that the Korean banking system supplies only to a limited extent, was visibly lower. It was not possible to ascertain the extent of the low-interest loans flowing into Korea's semiconductor industry. Based on divergent estimates by local interviewees, such loans amounted to a 5-30-percent share of total investment volumes. At present, however, the large semiconductor firms are deliberately discriminated against in the allocations policy because of the administration's mid-size business orientation and its anti-chaebol policy. But they are not absolutely excluded from the "policy loans." Chaebols are automatically preferred by the commercial banks in allocating free loan quotas not tied to conditions[3].

From Korea's viewpoint, access to the Euromarkets, at the latest since the end of the eighties, have provided the chaebols an interest advantage since they can borrow capital there on favorable terms, only slightly above the LIBOR [London Interbank Offered Rate] (3-4 percent for Samsung in 1994, somewhat higher rates for Hyundai and Goldstar). Actually they got this privilege because of their global activities and their fine credit rating, but they are also authorized for it in virtue of government approval. It is conjectured that the five leading groups currently realize ca. 50 percent of their external financing on the international monetary and capital markets.

The alternative for cross-subsidization inside the groups is also crucial for the chaebols' ability to invest enormously and opportunely in memory chip production. High profits from other segments can be used for investments in R&D and capabilities. They are applied towards offsetting the steep initial losses during the market entry phase. Such a strategy necessarily presupposed corporate readiness to take risks and willingness to make it through a long dry period. In this context, the chaebols' strict hierarchical-authoritarian leadership organization is an advantage.

According to the official version, no direct subsidized investments are granted. But there are indications that financial assistance is granted:

—in 1986, Goldstar took over the production facilities of the government's ETRI on terms that are not known in detail (Bloom 1992). In this way the delayed market entry of Korea's third DRAM supplier was facilitated.

—According to statements by interviewees in Korea, equipment and apparatuses that the producer acquired through direct R&D subsidies or tax breaks were also used in production.

Korea's tax system favors investment in new technologies, in plants that increase productivity or save energy or help protect jobs or the environment. In this context, investing firms have an option. They can either charge 3 percent of the acquisition costs (10 percent, if the acquired asset stems from Korean production) in the year of acquisition to the corporate tax or deduct 30 percent of the acquisition value (50 percent, if the acquired asset stems from Korean production) as deductible expenditures from gross receipts (DKIHK 1993).

The central government does not provide reduced-cost industrial acreage to the domestic semiconductor industry. It may be conjectured for the local level since this factor is an important reason for setting-up shop because of the scarcity of acreage and high real-estate prices.

Installation of foreign producers, especially from the U.S., is actively encouraged. In this context, an association with a domestic partner is prized. In this connection there are import restrictions for specific products. The nation's interest in installations has recently shifted to operations of Korea's Semiconductor Association [KSIA] in the area of the equipment and apparatuses industry. In Chonan municipality's industrial park, south of Seoul, 94 square kilometers of industrial acreage were set aside for that sector and should provide space for 16 firms willing to set up there.

Footnotes:

1. Traditionally, Korea's banking and financial system has been characterized by a notorious shortage of capital. The unbalanced structure is brought about by the features of government fixed interest, monetary overheating and rationing of foreign exchange. In the developing nation of Korea, the financial system, on the Japanese model, constitutes an intensely used instrument for increasing domestic investment and for allocating capital to strategic branches of industry. Contrary to the development status of the national economy, in Korea, in the past, just plant and capital intensive branches were supported. With interests rates fixed too low contrary to the market, the general economic policy goals of capital accumulation and

allocation are realized by stimulating compulsory savings and foreign currency controls on the level of private households plus strict monitoring of the total interest structure, direct interventions by the authorities and quantitative loan limitations on all loan and capital movements. As a consequence, in the ongoing monetary overheating, there is a surplus demand for capital on the part of companies that see the possibilities for their economic expansion limited only by a shortage of capital. There has been only slight change to this structure despite the currently undertaken liberalizations and deregulations.

2. Korea enjoys no general interest rate advantage. Contrariwise, real interest in Korea is higher than the average in industrial countries. Korea's structural shortage of capital as a "developing country" accounts for this difference as well as the segmentation of the financial and capital markets limiting investors' opportunities for diversification. Only a handful of firms or branches continues, however, to enjoy favorable loan terms. The upshot is a simultaneous exaggerated worsening of the financing terms of nonprivileged firms.

3. At the start of 1994 this was a maximum 30 percent of commercial banks' loan volume.

7.5 Restrictions on Market Access

Because Korea's exports are concentrated on a single product and because of the intense dependence of semiconductor products and technologies on overseas, foreign trade is the Achilles heel of Korea's semiconductor industry and the competitive strategies it threatens. The major goal of foreign trade policy, therefore, is the avoidance of foreign policy conflicts and a reduction of the intensity of foreign perception of growing competition from Korea. To this effect, the primary task of government agencies in the foreign trade sector lies in conflict management and information policy. Alongside the official responsibility of the MOTIE, KSIA has a quasi governmental function as a negotiator in pricing and quantity agreements and in monitoring of Korean exports. In addition to this "foreign trade policy" safeguarding of corporate competitive strategies, government agencies shape market access to Korea and the firms' export strategies via legislation and various administrative regulations.

Semiconductor products and equipment are subject to a 7.9-percent import tariff. Depending on the product, the tariff for semiconductor materials amounts to 6-8 percent. Actually, however, Korean firms pay only 5.2 percent on semiconductor equipment. This measure is supposed to facilitate technology transfer to Korea. Firms that produce in the export zones for the worldwide market do have a total exemption from tariffs. MOTIE is planning to entirely abolish tariff protection for semiconductors by cutting tariffs by 12-30 percent annually between 1994-1999, respectively.

There are specific nontariff trade barriers to market access for semiconductors to Korea, although they generally play no major role. For instance, on the level of consumer industries, there are restrictions on quantities and local content rules, exclusively for Japanese products. This is a blatant violation of prevailing GATT [General Agreement on Tariffs and Trade] provisions, although Japan has not lodged any official complaint. On the level of the offshore equipment and materials industry, the government and firms pursue a "buy American" policy that is partially based on the restrictive behavior of Japanese suppliers in terms of technology transfer. This approach simultaneously counters trade policy pressure from the U.S. In the government's procurement system, domestic products, especially from small and mid-size enterprises [SMEs], are given preferential treatment, to the extent that there are domestic suppliers. Norms and standards apparently play no major part in market access for the semiconductor sector (in contrast to the consumer industries).

Within the chaebols, vertical and horizontal intertwining of firms constitutes an effective market barrier from a foreigner's optic. But it is less relevant for the semiconductor itself than for the consumer industries. Korea's competitive policy places no restrictions on vertical integration, although recently there has been some breaking up carried out on the horizontal level. The conglomerates are obliged to concentrate their activities on four selected branches.

Export support has always been a key element of Korea's externally-oriented economic policy focusing on growth and development. Exports are supported by tax measures, by customs tariffs, by loans and subsidies, by mediation and information supplied by institutions set up specifically for such a purpose (Sakong 1993). Still, no sector-specific support for DRAM exports can be detected.

7.6 Other Measures

U.S. and European firms accuse DRAM producers from Korea of selling their products overseas below the production price, meaning, they engage in dumping. Absent exact knowledge of Korean production costs, especially the yield curve realized by them, this charge cannot be either confirmed or refuted. Based on the remarks of independent local observers, Korean suppliers in fact did sell below price at the inception of their entry on the market, but they currently purportedly have the most efficient production facilities and are gleaning high profits from exports. Hence, at present, dumping is rather unlikely. Still, the imposition of antidumping tariffs and pricing pacts does burden to a not inconsiderable extent Korean imports, at least in the U.S.:

—As the result of an antidumping complaint by Micron technology, the U.S. "International Trade Commission" decided in late April 1993 on punitive tariffs for Korean DRAMs.

—U.S. antidumping tariffs were averted by a voluntary Korean price limitation. Korean suppliers consented, beginning on 18 March 1993, until 17 March 1997, to calculate their minimum sale price in the U.S. using the "production costs + 9.5 percent" formula.

7.7 Assessments

Inside of a decade, Korea's semiconductor industry developed virtually from zilch into number three on the global scale. In doing so it was actively supported by government industrial policy. To that extent, the controlling and regulating hand of the government has to be acknowledged to be a major success for Korea. Still, the strategic initiative always lay with the semiconductor firms, not the government. In this aspect, Korea is more similar to the western industrial countries than neighboring Japan and Taiwan. In Korea there is no industrial policy "master plan"; instead, the government authorities speedily and flexibly adapted themselves to industry's strategic requirements. The reason for the success, therefore, is more to be found in the firms themselves than in the government.

In Korea the most effective support is done by means of the availability of low-interest capital. The highest government subsidies are made for projects in the context of R&D. In fact, the acknowledged quantitative level of Korea's government support is high in a global context. Moreover, administrative regulation and structuring on the microlevel are not as intensive in any other of the countries that were studied, notwithstanding the numerous deregulatory and liberalization activities in past years. Unlike Japan, Korea does not shy from deliberately privileging specific firms on the basis of effectiveness, while disadvantaging others. Any assessment of Korea's official industrial policy, therefore, has to take account of the ultimate qualitative aspects, not the quantitative level, of the support amounts.

From Korea's viewpoint, the installation of foreign semiconductor firms was always a means to an end (technology transfer) rather than a goal in itself. While in the seventies and the eighties it was primarily U.S. companies that shifted the assembly process to Korea, at present a contrary process can be observed. Because of high wage costs and extensive regulations and restrictions, Korea presently is no long an attractive site for global market production. However, production for Korea's domestic market continues to be attractive to foreign suppliers.

If the government's industrial policy is to be assigned only a supporting role, what are the reasons for the success of the phenomenal ascent of Korea's semiconductor industry? They are primarily the firms' readiness to face corporate risk and the groups' ability to make enormous investments quickly and without compromises. Capabilities are being deliberately expanded and modernized. Capital, technology and the labor force are being rapidly mobilized. For example, to set up its DRAM factory (4 MB and 16 MB) in Inchon took Hyundai just seven months. In terms of flexibility and speed, Korea's chaebols are especially superior to Japanese firms where the internal decision-making process is generally time consuming and drawn out. In terms of capital strength they are both evenly matched. It is worth noting, however, that the structure of Korea's economy favors the large industry embedded in the groups.

The second reason for the success lies in the firms' ability effectively to implement the strategies being pursued. In this context, management is able to resort to its experience in the process of catching up industrially and to orient itself on the U.S. and Japanese pattern. A major competitive factor is based on the high motivation, physical endurance and talent for precision work of Korea's labor force.

The trade policy environment towards the end of the eighties proved to be favorable for Korea's DRAM manufacturers. From the U.S. point of view, Korea served as a natural ally against looming Japanese market domination. Hence, U.S. firms willingly and readily granted licenses for technologies in which Japan had driven them out of the market. Concurrently, Korean suppliers were able to exploit the forced restraint of Japanese firms in the memory sector resulting from the U.S.-Japanese semiconductor pact for a successful positioning on the global market. On the other hand, Korea's assessment as a "second Japan" definitely double-edged since it has made a lasting impression on U.S. foreign trade policy.

The single-product focus of Korea's semiconductor industry raises the hypothetical question of the costs of such a strategy. In a global context, the steep outlays for licensing (ca. 12 percent of revenues (KDB) constitute measurable costs. More significant, however, are likely to be the development opportunities in the non-memory segment that were forgone. Equally unquantifiable are the trade policy conflicts engendered by the lopsided concentration on highly sensitive DRAMs.

The future development prospects of Korea's semiconductor industry have to be assessed as extremely favorable. The firms will intensely effect the needed technology transfer to Korea by means of international alliances. Because of their realized competence in the memory sector they have now become attractive partners. The reason for any association with Japanese rivals is to accumulate capital and reduce risks; alliances with U.S. partners target complementary associations (financial strength and process technologies, U.S. innovation and technological potential, access to U.S. consumer markets).

For Korean manufacturers the greatest risks lie in the political area. Access to open export markets and foreign technology is a key requirement for further expansion. However, even Korea's economic policy may constitute a risk for its domestic electrical engineering industry. The mid-size orientation and the anti-chaebol policy of Korea's economic policy, the conflicts between government and large industry that have by now become virtually traditional, could, negatively impact flexibility and an ability to expand in a branch in which critical size is a crucial factor.

TAIWAN

8.1 Taiwan's Semiconductor Industry

Taiwan annually produces semiconductors worth ca. DM4 billion, after converting currencies, and consumes ca. DM7 billion worth. Gauged by production volumes, Taiwan's industry in 1993 realized a global market share of 2.7 percent (1992: 2.1 percent).[1] The level of self-supply remains slight. It is estimated that 70 percent of the rapidly growing domestic demand, entailing an annual growth rate of 15-20 percent a year, is currently being covered by imports from the U.S., Japan and neighboring Asian countries (Malaysia, Korea, Hong Kong, primarily). Semiconductors still lead crude oil as the country's major import commodity in terms of volume. Export rates, in turn, are likewise similarly high (see table 8.1) because of Taiwan's firms' specialization in assembly under contract.

Compared to Korea, Taiwan's semiconductor industry has a much larger technological breadth, but so far it has not been able to achieve any absolute top position in any segment. The majority of the ca. 200 domestic semiconductor industry has specialized in chip design and software. Somewhat more than 10 firms produce integrated circuits. All firms having industrial and technological potential are located in the Hsinchu science park situated 80 km south of Taipeh. There were 42 such firms in early 1994.

Currently, Taiwan's production and exports are still mainly focused on the lower and mid-range technological categories. Only in 1993 was a breakthrough made in leading-edge technology. In 1994 five firms (TSMC [Taiwan Semiconductor Manufacturing Company, Ltd], UMC [United Microelectronics Corp.], TI-ACER [joint investment by Texas Instruments Inc. of the U.S. and Acer Inc, Taiwan's largest computer company], Hualon, ERSO [Electronics Research and Service Organization) will have or realize production facilities based on 9-inch wafers and 0.5-0.35μ technologies; two additional firms (Winbond, Macronix) also want to establish facilities in such technology at a later time.

Table 8.1: Growth of Taiwan's Semiconductor Industry—In Millions of DM

Year	Market volumes	Production	Exports	Imports
1989	5,215	3,638	2,924	4,501
1990	5,354	3,310	2,458	4,502
1991	7,304	4,003	2,885	6,186
1992	6,385	3,883	n.a.	n.a.
1993	7,992	n.a.	n.a.	n.a.

Sources: American Institute in Taiwan (Wang 1991 and 1992), Industry Technology Research Institute. Original data in U.S. dollars.

This aggressive investment strategy will lead to overcapacities. The firms therefore will endeavor to expand their market presence in the industrial countries.

On the product level, Taiwan's industry was also able to realize breakthroughs. Three firms (UMC and the U.S.'s AMD [Advanced Micro Devices Inc.] and Cyrix) are producing (486 SX) microprocessors. Macronix is producing 32-bit RISC [Reduced Instruction Set Computer] central processing units. On the global scale, Taiwan's industry is most effective in the ASICs sector. The high level of Taiwan's competitiveness in this segment is based on the creativity and speed of numerous independent chip designers and the extensively developed division of labor in the production of ICs. In contrast, the apparatuses industry in Taiwan is stuck in the early stages. The demand for equipment is virtually covered exclusively through imports and, in fact, half of them from the U.S. and half from Japan.

The development of Taiwan's semiconductor industry to its current effectiveness can be accounted for—besides support from a comprehensive industrial policy already applied early on—by the interaction of basically two factors, a technological push based on extensive investments by the U.S. semiconductor industry and a demand pull from Taiwan's computer industry.

Direct U.S. investments since the seventies have led to the development of semiconductor production facilities locally and brought about a broad and intensive transfer of technology. It is estimated that 20 percent of the engineers engaged in the semiconductor industry in Silicon Valley are of Chinese origin. In labor and management of both U.S. and Taiwanese firms, Chinese returning to their homeland have used their know-how and creativity to contribute decisively to the development of Taiwan's semiconductor industry. Taiwan's acknowledged strength in chip design and in the software sector is also attributable in particular to this "brain drain."

Powerful impetuses for growth arise from the demand of local consumer industries for semiconductors. This is especially true of the EDP [Electronic Data Processing] industry that consumes on its own 70 percent of all semiconductors sold in Taiwan and 74 percent of all ICs (see table 8.2). Because of successful sales of PCs (ca. one tenth of global market production), notebooks and ancillary peripherals (especially monitors, motherboards, scanners, networking equipment, mice, keyboards and terminals), Taiwan's EDP industry has developed into the fifth largest in the world. The effectiveness of Taiwan's computer industry is primarily based on the dynamism and flexibility of the mid-sized sector. As a result, Taiwan's computer industry is likely to be well equipped even for the looming turbulent era of multifunctional PCs and multimedia. Shifting of wage-intensive production to the Chinese mainland constitutes a competitive advantage that is gaining increased significance. It enables the preservation of cost advantages and facilitates participation in China's expanding market.

Table 8.2: Semiconductor Use in Taiwan by Branches—in percent

	Total semiconductors	Including ICs
EDP industry	70	74
Consumer electronics	15	16
Telecommunications	10	8

Source: American Institute in Taiwan (Wang 1991 and 1992).

Footnotes:

1. Taiwanese data that turn out to be somewhat higher than international production statistics, according to Dataquest. The difference is explainable by the OEM production of Taiwan's manufacturers or as a result of different product demarcations.

8.2 Philosophy of Economic Policy

As in Korea, so too in Taiwan industrialization was driven forward by the firm hand of an authoritarian development regime while at the same time the country's development was hemmed in by high defense outlays and a scarcity of its own natural resources. Compared to Korea, Taiwan's process of political and economic liberalization of the "planned free economy" was manifestly implemented more consistently and at present has advanced considerably farther.

Unlike Korea, Taiwan's economy is structured for the medium sized sector providing it with its recognizable high level of flexibility and dynamism. An additional difference between the two countries lies in Taiwan's high foreign trade openness, since it has only a rather small domestic market involving ca. 20 million inhabitants. By resorting to a development and industrialization strategy targeting the installation of foreign productive capital and technology from the very outset, Taiwan has successfully realized a definitely higher per capita GSP [Gross Social Product] when compared with Korea, although having a generally symmetrical distribution of income and wealth. Counterbalancing the export success of Taiwanese firms on the global markets is a high market penetration by foreign firms in Taiwan. Currently, through direct investments Taiwan is tightly tied into the global economy.

In order to be able quickly to succeed in catching up with the established industrial countries as the Taiwanese see it, the government has to play a key role in the economy on the basis of structuring the framework conditions in terms of a liberal western concept. In this context the role of the government was not limited not merely to undertaking the steep investments in human capital, stimulating savings and capital formation, accelerating sectoral change and supporting the export capability of the domestic economy. The government also stepped forward as an entrepreneur and in this manner induced the emergence of capital intensive economic branches like energy production, petrochemicals, steel and ship building in the past and in the present, aerospace and the semiconductor industry. Since the mid-size structured domestic industry did not engage in the indicated branches because of a lack of capital, minimum willingness to take on risk or too limited research intensity, it had to devolve upon the government to set up such a firm and its subsequent privatization (Gaelli 1993; Schueller 1993).

It is striking that the precise control of industrial policy on the meso- and microlevels, in comparison to Korea and Japan, is heavily tied to regulations and is effected only to a limited extent through direct interventions in the market process (for instance, using price and quantity controls or by means of administrative directives). Such measures are highly transparent both for the domestic industry as well as for third parties.

Industrial policy activities to stimulate the development of a domestic semiconductor industry began in 1974 on the initiative of the economic minister with the establishment of the "Electronics Research and Service Organization" (ERSO)[1] as a subsidiary of the government's Industrial Technology Research Institute (ITRI). In this way the key institution was created for planning and implementation of the government's technological and industrial policy for the domestic electrical engineering industry.[2] For successful implementation of microelectronic research and production in Taiwan, any structural industrial policy essentially had to oversee three tasks: first, initiation and organization of an extensive transfer of technology into the island republic, second, development of an autonomous industrial competency and, third, stimulation of domestic (mid-size and rather weak on capital) industry to invest and assume corporate risks (Hong 1992; Liu 1993; Mody 1991).

These ambitious goals were basically pursued in two directions: first, by means of implementation of domestic semiconductor research projects under ERSO's umbrella, second, by means of intense support for installation of semiconductor firms in the Hsinchu science city that had been established in 1980. Reduction of market entry costs, that the mid-size, short-term profit-oriented firms in the country were not able or even willing to shoulder, as well as providing an effective semiconductor infrastructure in a central location are considered legitimate government responsibilities.

Semiconductor technology occupies a key position in the development plans and industrial policy concepts for the nineties. Taiwan's vision of a mature, net product intensive national economy emphasizing qualitative aspects (environment, social conditions, leisure time) is supposed to realized through further development and expansion of high-tech industries. In addition to the semiconductor industry, the EDV industry, consumer electronics and telecommunications are also included in the 10 strategic industries of the current national development plan.[3] The metropolitan "Hsinchu Zone" is

supposed to develop from the science city of Hsinchu and become a model for other regions in Taiwan.

Footnotes:

1. Until 1979: "Electronics Industry Research Center."
2. Taiwan's other institutions having industrial policy responsibility are less closely charged with the specifics of semiconductor technology and industry. The Office for Industrial Development under the Economic Ministry encompasses the design and structuring of sectoral support policy measures. The National Science Council coordinates and evaluates the country's R&D activities. In 1979 a technologically versed group of consultants was created with the establishment of the Technical Advisory Committee consisting chiefly of U.S. experts. Subsequently, the industrial policy development of Taiwan's semiconductor industry was accompanied by ongoing debates on strategies and concepts. The government's Chiao Tung Bank (formerly: "Bank of Communications"), the executive Yuan and the Hsinchu science park also dispose of autonomous development funds.
3. The other six economic branches are automation technology, aerospace, new materials, chemicals and pharmaceuticals, medical technology and environmental technology.

8.3 R&D Support

In terms of technology acquisition, transfer and dissemination, the government's ERSO has played the lead role in Taiwan. Without its steady support Taiwan's semiconductor industry would probably not have been able to develop to its present effectiveness. In four domestic research projects technological competence was gradually developed in all phases of the IC production process and passed on to private industry via spin-offs or through other channels (see chart 8.1). The heavy support for design process is remarkable. It was the DRAM shortage in the late eighties that first brought about a greater concentration on the capability for integration and kicked off the current "sub-micron" project (Liu 1993). ERSO's continued commitment to the 64 MB DRAM/16 MB SRAM [Static Random Access Memory] technology is currently not planned for. The efforts are to be autonomously continued by the industry that has grown to industrial maturity. ERSO shouldered the total costs of the first three projects. In the "sub-micron" project, industry, represented by the firms UMC and TSMC (plus a symbolic contribution from the firms Etron, Holtek, MXIC, Mosel, Vitelic, Winbond), is sharing for the first time half of the current costs. The firms have received low-interest loans to do so. ERSO is making its laboratory and a hundred development scientists available and it is financing the acquisition of equipment and devices.

At present, alongside the "sub-micron" project there are a number of other domestic research projects that are targeting industrial development of semiconductor technology or applied technologies, under the overall leadership of ERSO or other institutions:

1) In ERSO's "Microelectronic Component Technology Development Project" (1993-1996), signal processing, data storage and signals input and output technologies are under development.
2) ERSO's "Electronic System Package Technology Project" is focused on process development of chip bonding.
3) In the Hsinchu science park's "Nano Device Laboratory," financed exclusively by the government, gauges of 0.35μ are to realized by 1995, and gauges of 0.25μ, by the year 2000.

Chart 8.1: Taiwan's National Semiconductor Projects 1976-1993

	Development phase I	Development phase II	VLSI integration	Sub-micron
Time period	1976-1979	1979-1983	1983-1988	1990-1995
Official R&D outlays	489 NT dollars	796 NT dollars	2,921 NT dollars	$200 million
Goals and responsibilities	Development of preliminary pilot production	Development and expansion of semiconductor infrastructure	Development of a production line, including production of masks	Development of technological competence in IC production in gauges down to 0.35μ,
	Contract production for Taiwanese firms	Production of photomasks	Development of CAD design capabilities	Cooperation of government's ERSO laboratory with Taiwanese private industry (UMC, TSMC, Etron, Holtek, MXIC, Mosel, Vitelic, Winbond)
	Advanced training	Learning latest process technologies	Development of technological competence in the VLSI field	

Chart 8.1: Taiwan's National Semiconductor Projects 1976-1993 (Continued)

	Development phase I	Development phase II	VLSI integration	Sub-micron
Time period	1976-1979	1979-1983	1983-1988	1990-1995
Goals and Responsibilities (continued)	Acquisition of technological competence in design and production of ICs	Development of competence in CAD design	Learning of latest process technologies	
	Technology transfer	Advanced training		
	Demonstration	Expansion of semiconductor technology to consumer industries		
Realized gauges	7.0μ CMOS [Complementary Metal-Oxide Semiconductor]	3.5μ CMOS	1.0μ CMOS	0.35 μ CMOS
Spinoffs		UMC (1980), Syntek, Holtek	TSMC (1987), Hualon (1987), Winbond (1988), Taiwan Mask Corporation (1988); various chip designers	

Source: Our own summary based on: Liu (1993), Howell, et al. (1993), ERSO; on-site research.

4) In the "System Design Chip Implementation Center" located in the Hsinchu Science park and sponsored by the national science council, application-specific chip designs are developed.

5) Since 1982, the "Materials Research Laboratories," another ITRI subsidiary institution, has been intensively busy with developments in gallium-arsenide technologies (Howell, Bartlett, Davis 1992).

6) Government industrial policy actively supports development efforts in major applied industries (HDTV, satellite development, LCD [liquid crystal diode], aerospace). ERSO is implementing national research projects in the fields of HDTV (1992-1996), LCD (1994-1997), industrial information technologies (1994-1997) and IECQ (1995-1997). There are also research consortiums under overall government management, for example, for IC cards, notebooks, X-terminals, etc.

7) Under the aegis of the economic ministry (MoEA) and the government Institute for the Information Industry (III), between 1992-1997 development programs are being implemented for a total of 42 products. The government is shouldering 50 percent of the expenses, the firm may resort to a low-interest loan for the remaining 50 percent. Initially (1 July 1992), an investment outlay totaling $1 million was provided for this project. The main thrust of the program is in the software sector that, on its own, accounts for 20 product developments.

Under the domestic research project and via other channels the ERSO transfers semiconductor to Taiwan's private sector. This simultaneously develops an effective infrastructure for the semiconductor industry:

—Upon conclusion of the domestic research projects, the acquired skills are privatized as spin-offs. The developers therefore continue their activity for the market on their own in initiative. Virtually all of Taiwan's domestic semiconductor industry resulted from this sort of transfer of individuals and equipment (see chart 8.1). The country's two largest firms, UMC and TSMC, were able to take over the production line of the second and third domestic research project, respectively, as startup equipment for setting up their own firms (Howell, Bartlett, Davis 1992).

—The patents and chip designs that are developed are passed on to interested companies free of charge or for minimum licensing fees. ERSO, however, also has its own centers in Silicon Valley to keep an eye on the technology. ERSO also directly acquires patents abroad.[1] The transfer of product and production specifications, process organizational know-how, CAD software is realized in a similar way (Howell, Bartlett, Davis 1992; Liu 1992).[2]

—Through information and continuing education activities (informational documents, seminars, conferences, etc.) by ERSO, semiconductor know-how is expanded and intensified (Liu 1993).

—ERSO has set up a design center for cost effective development of chip designs for systems applications (Liu 1993).

—ERSO offers an extensive menu of industrial semiconductor services to interested firms (Liu 1993):

—Sending R&D personnel for consultation or continuing education,

—Leasing of apparatus and equipment,

—OEM production,

—Implementation of developments on a contract basis.

Semiconductor firms located in Hsinchu received project-related R&D subsidies to a limited extent. In

Taiwan, semiconductor technologies R&D as well as R&D in general gets tax breaks. Licensing revenues are tax free (Ministry of Economic Affairs, Industrial Development Bureau 1990).

Private sector efforts to transfer technology to Taiwan in the past were occasionally supported financially:

—Through the availability of government development funding (by the cabinet) for the acquisition of U.S. firms (Wyse Computer in 1989) (Howell, Bartlett, Davis 1992),

—Through the availability of joint-venture capital for foreign semiconductor firms willing to set up shop and, in fact, by means of a second fund in the Chiao Tung Bank (1985: DM10 million; 1992: DM41 million).

Into the eighties Taiwan had the reputation of being a flagrant violator of intellectual property rights because of an absence or insufficiency of commercial legal protection (for patents, registered designs, know-how, software designs, trademarks, authorship). U.S. semiconductor firms complained repeatedly of design theft by Taiwanese firms (Howell, Bartlett, Davis 1992). Currently, the legal protection introduced or sharpened as a result of U.S. pressure provide comprehensive civil-law protection for intellectual property on the technical and legal levels. Chip designs too are legally protected by the "Integrated Circuit Topography Act" passed by the topmost legislative body in December 1992. Since such regulations are so recent, however, the problem is that legal methodology and legal practice in Taiwan have still not been developed. So far too, there is underdeveloped awareness of illegality in Taiwan when violating intellectual property rights. Hence it is not clear how far commercial legal protections are actually able to be implemented.

Footnotes

1. At present, according to remarks by local interviewees, the practice of government acquisition of licenses abroad does not apply.

2. This approach ended up cutting both ways. The possibility of being able inexpensively to access technologies led to an oversupply and inadequate producer profit margins.

8.4 Production and Investment Support

In 1980 the Hsinchu science park was established, aimed at encouraging the installation of high-tech firms and an autonomous development of technology by Taiwan. All manufacturing firms in Taiwan's semiconductor industry are located there. The semiconductor industry comprises 24 percent of the park's firms and 37 percent of the park's turnover. Other sectoral foci are in the EDV industry, telecommunications and optoelectronics. Only firms that meet specific criteria of technological intensity and sales profitability are allowed to set up and stay there.

This attractive industrial ambiance resulted from a deft choice of location and judicious infrastructure policy. Hsinchu affords a favorable transportation hub, attractive living conditions (leisure and sports facilities, English-language schools, available apartment rental space), proximity to two technical universities, developed areas for industrial use (buildings for leasing, acreage for leasing) and an extensive menu of industrial services (transportation and loading facilities, warehousing, administrative expediting of imports and exports, disposal of industrial waste and effluent, information services).

The park's buildings and properties are made available to qualified firms on favorable terms. Currently in the planning is an expansion of the park's acreage by one-third of its present extent and over the long term Hsinchu is supposed to form the core of a metropolis numbering 1.2 million inhabitants.

On the legal basis of the "Statute for Upgrading Industries" (1990) and the "Statute for the Establishment and Administration of a Science-Based Park" (1989), the semiconductor firms in Hsinchu science park receive numerous tax breaks for investments in semiconductor plants and equipment:[1]

(1) The depreciation period for investments in plants and equipment may be shortened to two years.

(2) Five to 20 percent, respectively, of the following expenses can be deducted from tax liability:

—for investments in automation and streamlining,

—for environmental protection,

—for R&D (see above),

—for advanced training,

—for creating an internationally known brand name.

The cumulative deductions may amount to a maximum 50 percent of tax liability.

(3) Any newly installed company in Hsinchu is exempt from corporate tax for five years. Since in the startup years a high-tech investment generally accrues few or no profits, the firm has the right to determine, on its own, the inception of the five-year tax exemption although this period has to occur at the latest two years after market entry.

(4) Investments for expanding firms already set up in Hsinchu enjoy a similar four-year tax exemption on the resulting proceeds from the investment. In this case the firm has the additional option of reducing total tax liability by 15 percentage points.

(5) In general, the top tax rate for firms in Hsinchu is limited to 20 percent of the corporate tax.

(6) On distributed revenue the shareholder gets a 20-percent income tax deduction as an incentive. If the firm's revenue is plowed into a reserve fund, taxes

are deferred until the cumulative reserves reach 200 percent of total capital. Once that threshold is crossed, the reserve formation is taxed at 10 percent.

Taiwanese semiconductor firms are able to experience a reduction of capital costs by utilizing low-interest loans. Both the government development bank (Chiao Tung Bank) and the cabinet (executive Yuan) grant loans for R&D and for investments in plants and equipment at an interest rate that is pitched at least 2.5 percentage points below the market interest rate.

Both institutions participate in the initial capital of spin-off firms to the degree that their existence is deemed a strategic necessity for the development of an effective semiconductor infrastructure in Taiwan. The endeavor is for all production steps of the IC production process to be performed in the country itself. In this way the private semiconductor industry is to be afforded the capability of freely capitalizing on its own potential for specialization. Examples of this process are the privatizations of UMC in 1979 (government participation: 44 percent), of TSMC in 1987 (government participation: 48.3 percent) and the Taiwan Mask Corporation in 1987. In the current year, 1994, the privatization of the government's "Sub-Micron Laboratories" is following the same pattern.

Footnotes:

1. Taken from: Ministry of Economic Affairs, Industrial Development Bureau (1992); Ministry of Finance, Taxation and Tariff Commission; Science Park Administration, previously cited year.

8.5 Restrictions on Market Access

There is open access to Taiwan's market for semiconductors, semiconductor equipment and materials, not least in the interest of domestic consumer industries that depend on a smooth purchase of their key products from abroad. Taiwan has not concluded any bilateral market agreements in the semiconductor sector. It should be mentioned that Taiwan is not a member of GATT. Hence the island state is not subject to GATT's multilateral regulations; in turn, however, neither is it protected against protectionism and unilateral trade measures by third-party countries.

A "harbor tax" totaling 0.5 percent is levied on all imports to Taiwan. The import tariff rate on semiconductors comes to 0-1 percent. Equipment and materials for semiconductor production are liable for 5-10 percent. The import tariffs do not apply if the imported merchandise is reprocessed for re-export in a firm domiciled in the "Hsinchu Science Park" or utilized as a capital asset.

There are virtually no nontariff trade barriers for semiconductors. At most, some discrimination does occur as a result of government procurement activities. Public enterprises and institutions are theoretically obligated to give preferential treatment to domestic suppliers, especially mid-size firms, to the extent that they are capable of supplying a product of comparable value whose acquisition price does not exceed the importer's final price by more than 5 percent. Local experts claim that such regulations have no effective impact on the government procurement market for semiconductors and products of downstream industries. But there is veiled discrimination against Japanese suppliers since the purchase of non-Japanese products is de facto preferred by the government agencies.

Vertically integrated supplier ties play practically no part as a result of Taiwan's mid-size structure. ACER, the country's largest computer firm, constitutes an exception, since it derives a major portion of its semiconductor memories from the proprietary joint venture production with Texas Instruments (TI-ACER).

There is indirect export support as a result of the favorable export terms for firms sited in Hsinchu Science Park arising from central transportation and loading facilities, simplification of administrative procedures for foreign trade (issuance of export and import licenses, on-site drafting of certificates of origin) and the elimination of indirect taxes, the "business tax" and import duties.

8.6 Other Measures

Since the seventies the main thrust of Taiwan's education policy has been on the training of electrical engineers for the domestic information and semiconductor industry. Since the shortage of engineers and technically skilled labor had grown into a major chokepoint for the semiconductor and information industries, special training centers were created outside of the university sector. The "Computer Communicate Laboratory" (CCL) under ITRI's purview offers hardware programs and the III software programs. The Office for Industrial Development, on its own initiative, conducts basic and pre-university level curricula for the information industry. By the end of 1993, 1,500 engineers had been trained at it.

For continuing education in the private sector—a weak point in Taiwan's mid-size industry—the III set up two training centers, one each for the commercial labor force and for the technical management force (gee 1990). Special continuing education courses are offered for the semiconductor's skilled workforce in Hsinchu Science Park. In fiscal year 1992/93 those programs enrolled 1,620 individuals (1991/92: 2,061).

8.7 Assessments

The development of industrial capabilities has been and is being supported in Taiwan by comprehensively designed endeavors on the R&D, infrastructure development and investment levels. It may be conjectured that, among the East Asian countries studied, the relative scope and intensity of Taiwan's support are the highest.

In hindsight, the industrial policy support of the domestic semiconductor industry was designed in the

planning works for the long term from the outset and it effectively and successfully shaped industrial development. The success of Taiwan's semiconductor industry is based on three factors: first, the generally exceptional siting conditions for industrial production,[1] second, the steady "brain drain" from Silicon Valley and, third, the demand pull of Taiwan's EDP industry. Industrial policy has developed on these conditions and helped a vibrant, typically mid-sized industry succeed. Among Taiwan's numerous industrial policy activities, the national research projects for development of a domestic technological competency and liberal support for investment and production are likely to have been the most significant. Local experts who were surveyed claim that the government's industrial policy ranks high as on factor explaining the development and success of Taiwan's semiconductor industry.

Whereas in Japan industrial policy is pursued in rather close cooperation between private sector and government, and in Korea the economic policy climate is marked by confrontation, in Taiwan overall industrial policy management clearly resides with governmental authorities. The initiative for originating and developing a domestic semiconductor industry in the island republic emerged from government agencies, especially from the MoEA, that embarked upon development of ERSO in the early seventies under the leadership of Minister Y. S. Sun. The decision-making and opinion-building process was and is done openly and transparently, and includes foreign experts.

Unlike Korea and Japan, Taiwan was and is able to implement an industrial policy free from foreign trade constraints and foreign pressures. There are a number of reasons for that. Access to the market on Taiwan is unhindered. Foreign firms may participate in the growing domestic market by means of imports, direct investments and technology transfer. The strategy for industrially catching up is not concentrated on single products that subsequently clog up the global market by their presence. Instead, the industrial policy is designed for broad technological dissemination, global integration and import substitution. The result of this is only a few points of friction with overseas.

The future prospects for Taiwan's semiconductor industry may be assessed as excellent. The indicated strengths (cost and siting advantages, international networking, growing domestic market, flexibility and dynamism of the mid-size sector) should prove sustainable even over the medium to long haul. Taiwan's firms will continue their successful strategy; that is, on the one hand, nipping at the heels of pioneering technological developments with a justified R&D outlay and, on the other hand, focusing on the production of smaller batch sizes. In this way it is likely to succeed in continuing to be present on the global market in a timely fashion with technologically competitive products and make excellent profits. The current massive development of capabilities will result in a stronger present on the global market. Medium-term problems, however, may increase for Taiwan's semiconductor industry in the area of natural resources. Local experts report that Hsinchu has a water problem. And public acceptance of nuclear energy in Taiwan is dwindling.

Footnotes:

1. BERI, the U.S. economic research institute, attributes the second best investment climate, after Japan, to Taiwan in its annual countries analysis (Gaelli 1993).

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